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U.S. DEPARTMENT OF THE INTERIOR
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DISTRIBUTION, ECOLOGY, and HABITAT MANAGEMENT

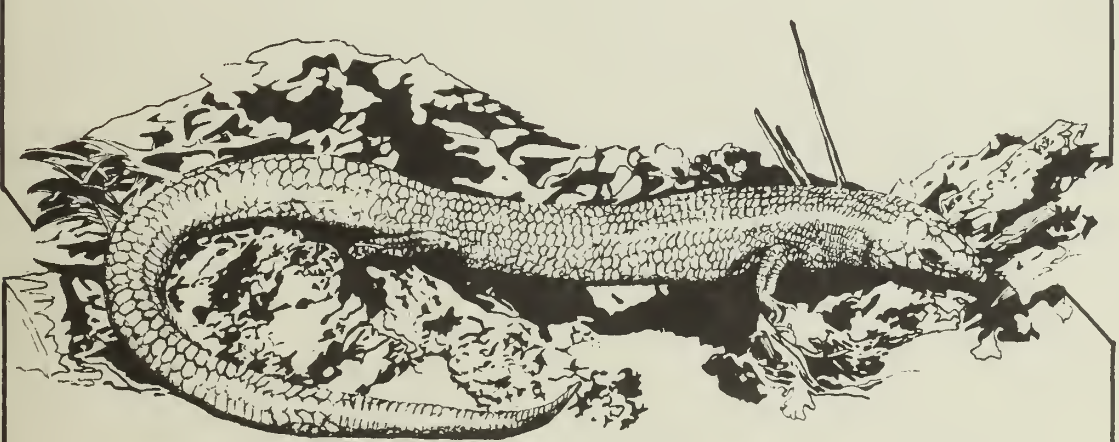
of the

REPTILES and AMPHIBIANS

of the

HUALAPAI-AQUARIUS PLANNING AREA,

MOHAVE and YAVAPAI COUNTIES, ARIZONA



by

Kenneth Bruce Jones

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DISTRIBUTION, ECOLOGY, AND HABITAT MANAGEMENT OF THE REPTILES AND AMPHIBIANS OF THE HUALAPAI-AQUARIUS PLANNING AREA, MOHAVE AND YAVAPAI COUNTIES, ARIZONA

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ABSTRACT

Relative abundance, species diversity, habitat use diversity, distribution, and ecological relationships were determined for eight species of amphibians, four species of turtles, twenty-three species of lizards, and twenty-six species of snakes. Of the sixty-one species of reptiles and amphibians verified within the Hualapai-Aquarius planning area, twenty-seven were range extensions which demonstrates the need to inventory public lands by habitat type.

Bufo punctatus was the most abundant amphibian and also possessed the greatest habitat use diversity. Cnemidophorus tigris was the most abundant and habitat diverse lizard throughout the planning area. Crotalus atrox was the most abundant snake while Salvadora hexalepis had the highest habitat use diversity among the serpentes.

Saguaro-palo verde, cottonwood-willow, creosote bush, and canotia mix standard habitat sites had the most diverse and abundant herpetofauna and upland standard habitat sites (e.g., ponderosa pine) the least diverse and abundant herpetofauna.

Certain species of reptiles and amphibians were found to possess limiting ecologies which I felt justified separate management considerations. Other management recommendations were made based on faunal richness of each standard habitat site, habitat conditions, habitat structural requirements, and conflicts (e.g., livestock grazing) that I felt are reducing the fitness of the area's herpetofauna and will continue to do so in the future.

Numerous studies in Arizona have described the ecology of individual species of reptiles and amphibians (Zweifel and Lowe 1966; Parker 1972: Parker 1972b; Pianka and Parker 1972; Vitt and Ohmart 1974; Pianka and Parker 1975, to name a few). Few studies however, have dealt with the ecology and distribution of entire communities of reptiles and amphibians over varied habitat types (Hanna et al 1975; Ohmart and Stephenson 1975; Jones unpub. data.

West-central Arizona has received little or no attention regarding either individual species or overall herpetofauna. The Bureau of Land Management, Phoenix District, is obligated to compile information on reptiles and amphibians for west-central Arizona, specifically the Hualapai and Aquarius planning units, for a grazing environmental statement.

Because of the total lack of information on reptiles and amphibians for the two planning units, the Bureau of Land Management had to undertake extensive herpetological inventories (the two planning units have a combined area of 1.4 million acres). To further complicate lack of existing data, the two planning units possess interior chaparral and pine-oak woodland (Brown and Lowe 1974a and 1974b; Brown and Lowe 1975), atypical of adjacent habitat for several miles in any direction. Many field guides have overlooked these isolated vegetative stands and

illustrate species distribution typical of desertscrub communities (with the exception of Stebbins, 1966, regarding an isolated population of the Sonoran mountain kingsnake, Lampropeltis pyromelana).

I contended that many of the reptile and amphibians known from central Arizona plateau region occur within isolated stands of interior chaparral and pine-oak woodland of the Hualapai and Aquarius planning units.

This document gives a total distributional account of reptiles and amphibians by vegetative community (standard habitat site, BLM 1977). It also assesses ecological parameters and population dynamics of resident herpetofauna and makes habitat management recommendations based on such determinations.

DESCRIPTION OF STUDY AREAS

Located south and southeast of Kingman, Arizona, in Mohave and Yavapai counties (Fig. 1), the Hualapai and Aquarius planning area is characterized by Upper and Lower Sonoran, and Transition Life Zones (Brown and Lowe 1974a and 1974b). Fourteen standard habitat sites (SHS) (in conjunction with BLM Manual 6602, BLM 1977) were established from these Life Zones: two Transition, six Upper Sonoran, and six Lower Sonoran (for their location see Appendix 8). Riparian standard habitat sites (SHS) were grouped with Life Zones they transected.

Certain SHSs had physical features that rendered site-specific, species distribution. These features are discussed in this section.

STANDARD HABITAT SITES

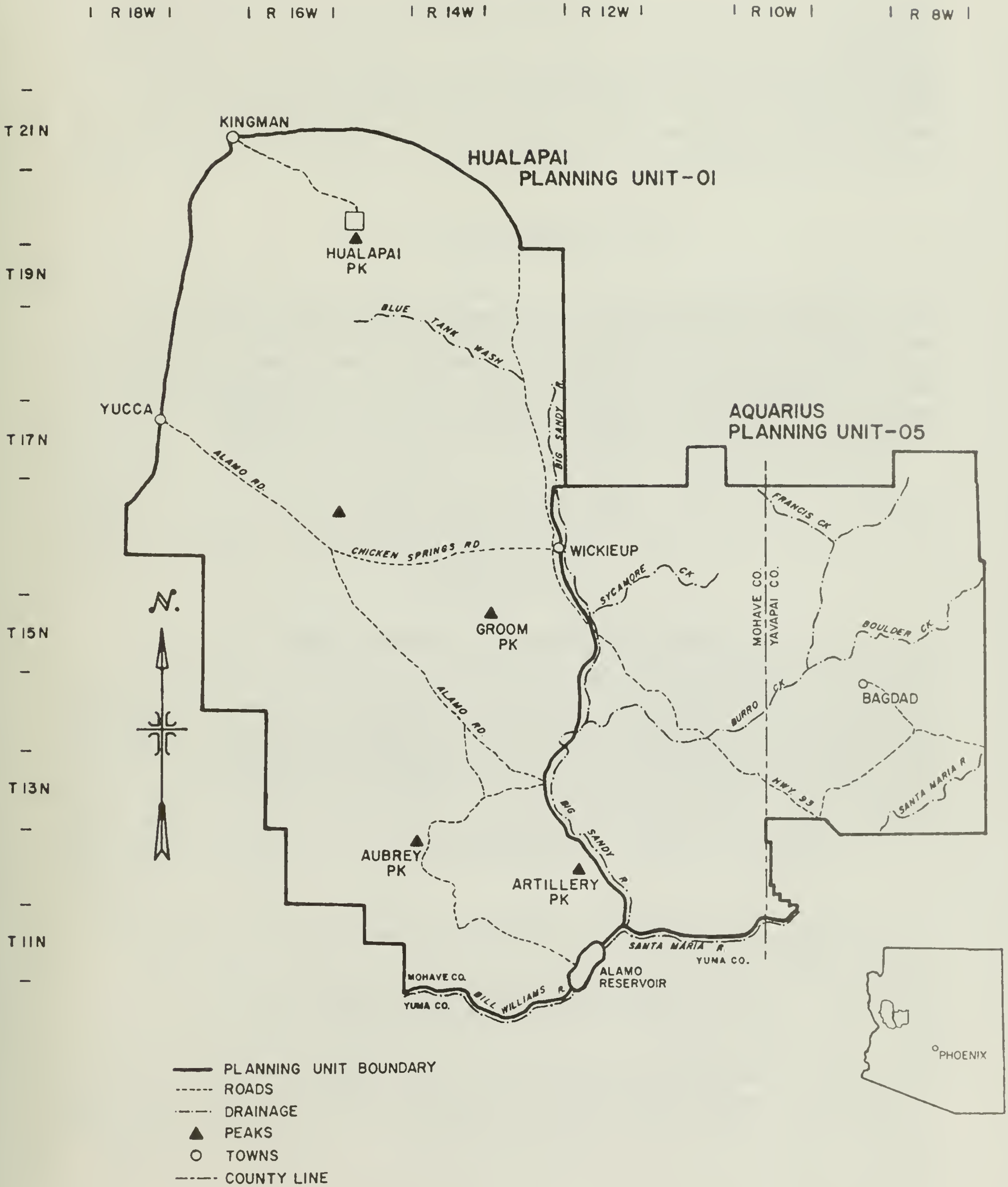
Following are descriptions of each SHS within the two planning units.

Transition Life Zone

Ponderosa Pine

Ponderosa pine study sites occurred in northern sections of the Hualapai Mountains at elevations ranging 6,500 - 7,500' where annual precipitation ranged 20-24" (Soil Conservation Service 1976). Ponderosa pine (Pinus ponderosa) was the dominanat overstory vegetative component, with local stands of Gambel oak (Quercus gambelii) also common. Understory

Figure 1. The Hualapai-Aquarius planning area.



composition varied from site to site, depending primarily on aspect and topography. Low percentages of understory occurred at some sites and high percentages at other sites. Where understory prevailed, scrub-oak (Quercus turbinella) and manzanita (Arctostaphylos spp.) were common. Skunk brush (Rhus trilobata) and yerba santa (Eriodictyon augustifolium) were also common at certain sites. Understory height ranged 1-5' and overstory height 20-75'. Large amounts of downed logs and litter occurred on the surfaces of this SHS.

Ponderosa-Aspen (Mixed Conifer)

Ponderosa-aspen SHSs occurred in small stands in the Hualapai Mountains between 7,400-8,300' where precipitation ranged from 20-24" annually (SCS 1976). Ponderosa-aspen consisted of an assortment of evergreens, the majority comprised of ponderosa pine. Other prevalent trees included aspen (Populus tremuloides), Douglas fir (Pseudotsuga menziesii), and white fir (Abies concolor). As at ponderosa pine SHSs, large amounts of downed vegetative litter occurred at this SHS.

Upper Sonoran Life Zone

Pinyon-Juniper

Pinyon-juniper occurred at elevations ranging 3,700-5,800' where annual precipitation fluctuates between 12-16" (SCS 1976). Vegetative composition varied greatly from site to site but in all cases had an overstory component of pinyon pine (Pinus monophylla) or juniper (Juniperus monosperma), or both. Major understory constituents included snakeweed (Gutierrezia spp.), paleleaf goldenweed (Haplopappus acradenius), and, in some areas, scrub-oak. Overstory height ranged 8-20' and understory height, 1-5'. Substrate varied, but was generally comprised of rocky, shallow soils.

Juniper Mix

Typically, this habitat consisted of a variety of plant species, but always possessed juniper as the dominant overstory component. Certain areas possessed 10-20 trees/section and others as high as 300/section. Unlike pinyon-juniper SHSs, juniper mix had a more diverse and varied understory. Rayless goldenhead (Acamptopappus sphaerocephalus) was the major understory component, and varying percentages of snakeweed, narrowleaf goldenbush, and flat-top buckwheat (Eriogonum fasiculatum) were also present. Overstory and understory height reached 15' and 5', respectively. Rock outcrops and large boulders dominated many areas of this SHS and Bigelow's nolina (Nolina bigelovi) occurred commonly at various locations. Partially decomposed limbs and trunks of this plant species help increase surface moisture retention. Elevation of this SHS ranged 3,500-5,500', and precipitation 12-16" annually (SCS 1976).

Closed Chaparral

Closed chaparral consisted of shrub cover in excess of 40%. By far, the most dominant plant was scrub-oak. Skunkbrush and manzanita also made up moderate percentages of the total vegetative composition. This habitat had most of its structural mass between 1 and 4'. Substrate varied but was generally rocky. Elevation of closed chaparral standard habitat sites ranged 4,300-6,500' and precipitation 12-20", annually (SCS 1976).

Open Chaparral

Open chaparral possessed shrub cover of less than 40%, and was typically dominated by scrub-oak, buckbrush (*Ceanothus* spp.), and mountain mahogany (*Cercocarpus* spp.). Sites adjacent to desert grassland SHS (Aquarius PU) had high percentages of tobosa grass (*Hilaria mutica*), three-awn (*Aristida* spp.) and shrubby buckwheat (*Eriogonum wrightii*) as the understory components. Open chaparral adjacent to closed chaparral had understory components consisting of desert needlegrass (*Stipa speciosa*), pigmy cedar (*Peucephyllum schottii*), and goldenweed. Both Hualapai and Aquarius sites had high percentages of snakeweed. Differences within this SHS for the two planning units resulted primarily from differences in range sites (SCS 1976). Elevation and precipitation ranged 3,700-4,700 and 12-16" per annum, respectively (SCS 1976).

Desert Grassland (Clay-loam, Mesa Tops)

Desert grassland standard habitat sites were restricted to mesa tops of the Aquarius planning unit and were dominated by large, volcanic rock surfaces. Dominated by snakeweed, nearly all vegetation was lower than 2'. Tobosa grass, three-awn, shrubby buckwheat, and catclaw (*Acacia gregii*) constituted the remainder of vegetation. Elevation varied 4,000-4,700', where precipitation ranged 16-20", annually (SCS 1976). Typically, these sites should be comprised of 80% perennial grass (*Hilaria*, *Aristida*, *Bouteloua*) (SCS 1976).

Lower Sonoran Life-Zone

Joshua Tree (Mohave Desertscrub)

Joshua tree SHSs occurred at elevations ranging 2,400-3,700', where annual precipitation varied between 8-12" (SCS 1976). Joshua tree (*Yucca brevifolia*) was the major overstory constituent, except when in ecotone with juniper mix SHSs. Understory vegetative composition was dominated by rayless goldenhead and snakeweed. Overstory height reached 20-25' and understory 2-3'. Soils were generally sandy with varying degrees of rockiness. Rock outcrops occurred within this SHS in isolated situations.

Creosote Bush

This standard habitat site was found primarily in the Yucca, Arizona vicinity at elevations 1,500-2,000', where precipitation ranged 7-10" annually (SCS 1976). Creosote bush (Larrea divaricata) and white bursage (Franseria dumosa) made up the majority of the vegetation. Overstory composition was quite limited; restricted to areas with a few Joshua trees and ocotillo (Fouquieria splendens). Overstory height, when present, ranged 10-20' and understory 1-5'. Substrate was generally a coarse sand with small diameter rocks on the surface.

Saguaro-Palo verde

This SHS occurred at elevations ranging 1,700-3,900', where precipitation varied between 7-12" annually (SCS 1976). Palo verde (Cercidium microphyllum) was the major overstory component. The understory consisted of several shrub species: range ratany (Krameria parvifolia), Mormon tea (Ephedra spp.), and rayless goldenhead. Moderate-height (4-7') vegetative components were dominated by creosote bush and buckhorn cholla (Opuntia acanthocarpa). Saguaro (Cereus giganteus) was common in isolated situations and gave a dominant overstory appearance but made up only a small percentage of the total vegetative composition and cover. Substrate was generally rocky, several sites consisting of rock outcrops and tallus slopes.

Canotia Mixed-shrub

Canotia mixed-shrub sites occurred at elevations ranging 3,000-4,000' where precipitation varied between 12-16" annually (SCS 1976). Mohave thorn (Canotia holocantha) was the major overstory constituent, and snakeweed, big galleta grass (Hilaria rigida), and rayless goldenhead were the major understory constituents. Canotia mixed-shrub occurred on sandy loam soils of rolling hills. Certain areas with increased clay in the soil had large stands of cholla (Opuntia spp.) and perennial grass (Hilaria spp.). In these areas, Mohave thorn dropped out. Both areas had high percentages of low-height shrubs, resulting in similar appearance.

Overstory vegetation reached 12' and understory 4'. Substrate was generally quite rocky, with limited amounts of rock-outcrops.

Riparian

Mixed Broadleaf

Mixed broadleaf riparian SHSs occurred at elevations of 2,500-5,000' that transected the Upper Sonoran Life-Zone. Precipitation ranged 12-16" annually (SCS 1976). Typically, this SHS had surface water or a high water table. Overstory was dominated by a variety of plant species: ash (*Fraxinus pennsylvanica*), walnut (*Juglans major*), willow (*Salix gooddingii*), cottonwood (*Populus fremontii*), and sycamore (*Plantanus wrightii*), with heights reaching 50'. Moderate height (4-15') vegetative components included skunkbrush, Fremont barberry (*Berberus fremontii*), seep willow (*Baccharis salicifolia*), and young willows. In some areas, overstory dominants demonstrated no reproduction. Understory components were limited to annual species (with the exception of limited amounts of seep willow, small scrub-oak, skunkbrush, and goldenweed). Substrate was rocky with limited areas of fine sand. Downed litter and branches predominated on the surface of this SHS.

Cottonwood-Willow

This standard habitat site occurred at elevations ranging from 1,700-3,500', transecting Lower Sonoran standard habitat sites, but not exclusively. In some higher regions of Francis Creek, this SHS transected the Upper Sonoran Life Zone. Precipitation at this SHS ranged from 7-12" annually (SCS 1976). The majority of this SHS occurred along Burro Creek and Big Sandy, Santa Maria, and Bill Williams River drainages. Isolated, small stands of this SHS occurred throughout small drainages in either planning unit. Cottonwood, Goodding willow, and mesquite (*Prosopis glandulosa*) made up the majority of the overstory vegetation reaching a canopy height of 50' in older stands. Although mesquite was present, it made up a minority of the vegetation. Understory components consisted of seep willow, catclaw, wolfberry (*Lycium* spp.), burro brush (*Hymenoclea* spp.), and white thorn (*Acacia constricta*). Substrate varied from sand to large rock.

Mesquite Bosque

Mesquite bosque SHSs occupied areas similar to cottonwood-willow SHSs along Burro Creek and the Big Sandy, Santa Maria, and Bill Williams River drainages. Unlike cottonwood-willow sites, the major vegetative component was mesquite. Catclaw also made up a large proportion of the vegetative community. Other low-to-moderate height (2-7') species included bursage, gray thorn (Zizyphus obtusifolia), desert broom (Baccharis sarathroides), and wolfberry. Maximum canopy height of mature stands reached 20', except where cottonwood occurred. Understory ranged 2-7'.

Elevation of mesquite bosque SHSs ranged 1,700-3,000' and precipitation 7-10" annually (SCS 1976). Substrate was generally sandy but rocky in certain areas.

METHODS

Species distribution and abundance by standard habitat site (SHS) were determined by use of an Array trapping method, road riding and field and canyon hunting between September 1978 and July 1979. The Array trapping scheme, a term coined by Campbell and Cristman (1977), uses a series of 5-gallon can traps placed in the ground and connected by aluminum fences. Campbell and Cristman used eight can traps with an open-center configuration. To save cost on drift fence and buckets, and to save time in their placement, we used four buckets with three radiating arms from a center bucket. Each of the four buckets was placed in the ground, their tops flush to the surface. Fences connecting buckets were anchored with stakes and wire, and extended 3 inches over the top of each can trap. Drift fence emanated from a center bucket, extending 25' at 120^{o} angles to end can traps. Arrays were marked and later checked at least once every three days. Animals collected in buckets were measured (mm., snout-vent), toe-clipped, sexed, and released. Forty-nine Arrays were placed in the planning area.

Quantitative Array data were analyzed exclusively for lizards and based on the number of lizards/4 trap nights which is the number of lizards caught/Array/night. Mean trap-night success for each habitat was compiled $\pm$ one standard deviation. Mean trap-night success of each SHS was compared for both individual species and overall lizard fauna. A breakdown of adult-juvenile lengths appears in Appendix 1.

Road riding, consisting of traveling roads day and night at speeds of less than 25 mph throughout delineated SHSs, was a method used to determine relative abundance of snakes (Appendix 6). Canyon hunting was utilized to determine amphibian relative abundance. Typically, it involved hiking canyons at night with flashlights, sampling spring sites, perennial streams, and dirt tanks. Appendix 4 illustrates amphibian (canyon hunting) sample sites.

Relative abundance (RA) was computed for amphibians and snakes by n_i/N (100); where n_i = number of the i^{th}species and N= total number sampled.

Data obtained by array trapping, road riding and canyon hunting were analyzed by the Shannon-Weinner H' diversity index (Orr et al. 1973),

$$H' = \sum_{i=1}^{s} p_i \log p_i$$

where s= number of species and p_i= the proportion of the total number of individuals consisting of the i^{th} species. Diversity indices were calculated for each SHS. Habitat use diversity (HUD) was calculated for each reptile and amphibian by the diversity index listed above; where p_i= the proportion of species abundance occurring in the i^{th} SHS.

Information on Chelonia was limited to field collecting due to small, isolated populations of turtles. Desert tortoise populations are under investigation by Betty L. Burge, and therefore, are only briefly discussed in this paper.

Special transects were used to determine relationships between ecological parameters and reptilian species. Transects estimating abundance of Heloderma suspectum were run to determine possible correlation with avian ground nests. Transects were 2,000' in length and consisted of walking straight lines and recording lizards seen within 50' of the line. Similarly, avian ground nests within 10' of the line were recorded.

To compare trap-night success of Phrynosoma with ant nest density, we obtained the number of ant hills along a 4,000', straight transect line, recording nests within 10' of the line. Transects were located at Array sites where data on Phrynosoma populations existed.

The relationship between downed vegetative litter and Sceloporus magister was analyzed from data obtained on SHSs and trap night abundance. All relationships between lizards and habitat variables were analyzed via simple regression.

Data on habitat structure, cover, and vegetative composition were obtained for fair and poor condition desert grassland SHSs and compared to lizard density, diversity, and population trends. Lizard density was based on Array data of each condition class. Student's t test ($p < .05$) were performed on lizard abundance to determine if differences observed between poor and fair condition desert grassland sites were significant.

Reptiles and amphibians are listed by scientific name only. Appendix 2 gives a cross-reference of scientific and common names.

SHSs are abbreviated in tables and figures throughout. Appendix 7 gives SHSs with corresponding abbreviations.

Voucher specimens of species possessing significant range extensions and unusual morphological features were taken and placed in the Phoenix District's Herpetological Museum.

RESULTS

Distributional and ecological data were obtained on 8 species of amphibians, 4 species of turtles, 23 species of lizards, and 26 species of snakes. Twenty-seven of these species represented significant range extensions of known distribution records (Appendix 3)(Jones et al. 1981).

AMPHIBIA

Overall amphibian abundance and diversity were dominated by the xerically adapted bufonid toads (Table 1). Bufo microscaphus and Bufo punctatus comprised more than 50% of the amphibian diversity for all SHSs combined (Table 1). Largest populations of these two species of toads occurred along intermittent and permanent water courses transecting various SHSs. Riparian SHSs were not a requirement for establishment of these species (Table 1). Both B. microscaphus and B. punctatus occurred sympatrically at elevations ranging 1,500-3,000' and allopatrically at elevations ranging 3,000-6,500'.

B. alvarius is known to occur at one locality--McGreggor Spring (Appendix 3). This specimen was an adult located in a vertical mine shaft with 6" of defined shoreline. Other than extending the known distribution of B. alvarius to the WNW, no conclusions can be drawn from one locality record.

Similar to B. alvarius, B. woodhousei was also found at only one location--the Big Sandy River (Appendix 3). Unlike B. alvarius, which occurs more frequently at dirt tanks and temporary water pools, B. woodhousei frequents sandy river drainages. With this knowledge, we can ascertain a hypothetical distribution for B. woodhousei (Appendix 3, includes the Big Sandy and Santa Maria Rivers).

The family Pelobatidae is represented by the species Scaphiopus couchi and, similar to B. woodhousei, was verified only along the Big Sandy River (Appendix 3). Populations of this species should occur on majority of the Big Sandy, Santa Maria, and Burro creek drainages (Appendix 3). This species of toad generally requires sand-bottom drainages.

The family Hylidae was represented by one species, Hyla arenicolor. H. arenicolor was the second most abundant amphibian and possessed the second largest habitat use diversity, occurring in all but three SHSs

TABLE 1 - Relative abundance (RA), species diversity (H'), and habitat use diversity (HUD') of 8 species of amphibians in 14 standard habitat sites. RA = n_i/N (100). N = the total number of amphibians. n_i = the total number of a given species. n' = the total number of amphibians within a given standard habitat site. n = the total number of species in a given standard habitat site. HS = the number of standard habitat sites a species occurried in. See Appendix 7 for standard habitat site abbreviations. Species diversity (H') = $\sum_{i=1}^{s} p_i(\log p_i)$ (Orr et al 1973); where s = the number of species and p_i = the proportion of the total number of individuals consisting of the i^{th} species. Habitat use diversity (HUD') = (H') except s = the number of standard habitat sites and p_i = the proportion of the total number of inidividuals occuring in the i^{th} standard habitat site.

	PP	PA	PJ	JM	IC	OC	DG	JT	CB	SP	CM	MB	CW	BR	HS	HUD'	n_i	RA
Bufo alvarius	----	----	----	----	----	----	----	----	----	0.33 (1)	----	----	----	----	1	0.00	1	0.33
Bufo microscaphus	1.00 (3)	0.33 (1)	---- ----	0.67 (2)	4.00 (12)	1.00 (3)	---- ----	---- ----	---- ----	---- ----	1.67 (5)	7.00 (21)	6.33 (19)	5.33 (16)	9	1.84	82	27.33
Bufo punctatus	----	----	4.00 (12)	3.00 (9)	1.00 (3)	1.67 (5)	----	4.00 (12)	2.67 (8)	1.00 (3)	3.67 (11)	1.33 (4)	4.00 (12)	1.33 (4)	11	2.29	83	27.67
Bufo woodhousei	----	----	----	----	----	----	----	----	----	----	----	0.67 (2)	----	----	1	0.00	2	0.67
Hyla arenicolor	10.67 (32)	1.33 (4)	0.33 (1)	1.00 (3)	3.00 (9)	0.67 (2)	----	----	----	1.33 (4)	1.00 (3)	----	5.67 (17)	0.67 (2)	10	1.74	77	25.67
Rana pipiens	1.00 (3)	----	----	2.33 (7)	0.67 (2)	----	----	----	----	2.00 (6)	1.67 (5)	----	8.33 (25)	0.67 (2)	7	1.54	50	16.67
Scaphiopus couchi	----	----	----	----	----	----	----	----	----	----	----	0.67 (2)	0.33 (1)	----	2	0.64	3	1.00
Ambystoma tigrinum	0.33 (1)	----	----	0.33 (1)	----	----	----	----	----	0.33 (1)	----	----	----	----	3	1.11	3	0.99
H'	0.65	0.50	0.27	1.36	1.18	1.03	0.00	0.00	0.00	1.40	1.28	0.86	1.41	0.99				
n'	39	5	13	22	26	10	0	12	8	15	24	29	74	24				
n	3	2	2	5	4	3	0	1	1	5	4	4	5	4				
RA	13.00	1.66	4.33	7.33	8.67	3.34	0.00	4.00	2.67	4.99	8.01	9.67	24.67	8.00				

N = 301

(Table 1). Similar to B. microscaphus and B. punctatus, H. arenicolor required intermittent and permanent watercourses (independent of riparian vegetation in certain areas). Tadpoles of this species occurred in standing pools supported by large boulders. Tadpoles were most evident between late May and July. Largest populations of H. arenicolor were found on Burro Creek, Francis Creek, and the Santa Maria River.

Of the true frogs (Ranidae), only Rana pipiens occurred in the planning area (Table 1), abounding in permanent, relatively calm pools of water. Because of high numbers over a limited area and number of SHSs, R. pipiens possesses a relatively moderate habitat use diversity (Table 1). R. pipiens was most common along Francis Creek, Burro Creek, the Big Sandy River, and the Santa Maria River, but may also occur at spring sites within other standard habitat sites (Table 1). Similar to H. arenicolor, R. pipiens distribution has most likely been extended by considerable precipitation over the past 2 years.

The salamanders were represented by the species Ambystone tigrinum of the family Ambystomidae. Because of difficulty in identifying subspecies of this salamander, we are uncertain as to whether A. t. nebulosum (native) or A. t. mavortium (introduced) were sampled.

An overview of amphibian diversity demonstrated cottonwood-willow riparian SHSs to possess the highest species diversity index, 1.41 (Table 1.). R. pipiens, H. arenicolor, B. microscaphus and B. punctatus comprised the majority of that index (Table 1). Pinyon-juniper SHSs had the lowest diversity, 0.21 (Table 1.). Since specimens were not collected in desert grassland, Joshua tree, and creosote bush SHSs, no value for diversity could be calculated.

REPTILIA-CHELONIA

Casual observations of the terrestrial species Gopherus agassizi were compiled to supplement data obtained by Betty L. Burge (1979). Data from both sources were then used to compile a tortoise distribution map (Appendix 3).

The family Chelyridae was represented by two species, Kinosternon flavescens, and Kinosternon sonoriense. Records were obtained only for the backwater canals of the Big Sandy River (Appendix 3).

Trionyx spinferus, of the family Trionchidae, may occur in limited areas along the Burro Creek drainage, specifically the confluence of Burro and Boulder creeks and the Big Sandy and Santa Maria rivers. These areas contain slow-moving pools with well-developed shorelines, requirements of this species of turtle.

The only verified records of T. spiniferus are from Alamo Lake. To date, three specimens have been taken, with photographs of each located in the Wayside Bar.

REPTILIA - SAURIA (LACERTILIA)

Cnemidophorus tigris was the most abundant lizard encountered within the study area except at higher elevations (Table 2). Higher elevations gave rise to Cnemidophorus velox and Cnemidophorus exsanguis, the more mesic, parthenogenic counterparts of the family Teiidae (Table 2). Although C. velox and C. exsanguis appear to be more ecologically compatible with higher elevation standard habitat sites than C. tigris, neither was abundant, 0.08 and 0.01/4TN, respectively (Table 2).

Similar to C. velox and C. exsanguis, Eumeces obsoletus and Eumeces gilberti demonstrated distributions tied to mesic habitats (Table 2). Ecologically, E. gilberti and E. obsoletus are similar to C. velox and C exsanguis. Both are considered widely-foraging species (Table 3), and like C. velox and C. exsanguis, they occur in small numbers (Table 2). The activity of teiid and scincid lizards were influenced by elevation, lizards at higher elevations commencing activity later in the spring than those of lower elevations. Where the distribution of E. gilberti and C. tigris overlap, E. gilberti were most active in early spring, and C. tigris in June (Figure 2).

Of the five widely-foraging species, only C. tigris has adult-juvenile and sex ratios and relative abundance typical of healthy, stable populations (Tables 2 and 4).

Sceloporus magister, a sit-and-wait forager, was the second most abundant lizard (1.74/4TN, Table 2), occurring in all but three SHSs. A comparison of downed litter (tree limbs, branches, and other plant matter) and S. magister populations demonstrated high correlation, r=0.86 (Figure 3). In upland communities, S. magister gives way to Sceloporus undulatus (Table 2). Similar to S. magister, S. undulatus thrived where downed vegetative litter predominated, especially in ponderosa pine standard habitat sites (Table 2). Rock substrate seems to be the ecological equivalent of downed litter at desert grassland habitat sites, as demonstrated by high populations of S. undulatus, the lack of downed litter, and the abundance of large rock substrate. The abundance and adult-juvenile and sex ratios of both S. undulatus and S. magister are

TABLE 2. Relative abundance (RA), species diversity (H'), and habitat use diversity (HUD') of 21 lizards within the Hualapai - Aquarius planning area. RA = the number of lizards caught/array/night. H' and HUD' are as in Table 1. For standard habitat site abbreviations see Appendix I.

Species	PP	PA	PJ	JN	IC	XC	DG	JT	CB	SP	CH	BR	CW	MB	Total RA	HUD'	Number of SHSs occurred in
Coleonyx variegatus	-	-	-	-	-	-	-	0.02±.02	0.05±.01	-	0.02±.02	-	-	-	0.09	0.94	3
Heloderma suspectum	-	-	-	-	-	-	-	-	-	0.03±.01	-	-	-	-	0.03	0.00	1
Callisaurus draconoides	-	-	-	0.04±.01	-	-	-	0.02±.08	0.03±.01	-	0.03±.04	-	0.02±.01	-	0.14	1.58	5
Cophosaurus texana	-	-	0.05±.01	-	0.04±.04	-	-	-	-	-	-	-	0.03±.01	-	0.12	1.08	3
Crotaphytus collaris	-	-	-	-	-	0.03±.04	0.05±.07	-	-	-	-	-	-	-	0.08	0.66	2
Dipsosaurus dorsalis	-	-	-	-	-	-	-	-	*	*	-	-	-	-	*	*	2
Gambelia wislizenii	-	-	-	-	-	-	-	-	*	-	-	-	-	-	*	*	1
Phrynosoma douglassi	0.03±.01	0.03±.01	0.12±.02	-	-	0.04±.06	-	-	-	-	-	-	-	-	0.22	1.18	4
Phrynosoma platyrhinos	-	-	-	0.03±.01	-	-	-	0.04±.06	0.15±.03	0.07±.02	0.15±.11	-	-	-	0.44	1.43	5
Phrynosoma solare	-	-	-	-	-	-	-	-	0.02±.01	-	-	-	-	-	0.02	0.00	1
Sauromalus obesus	-	-	-	0.10±.02	-	-	-	-	-	-	0.03±.04	-	-	-	0.13	0.54	2
Sceloporus magister	-	-	0.09±.02	0.11±.04	0.03±.07	0.08±.07	-	0.20±.04	0.07±.02	0.22±.05	0.27±.38	0.19±.04	0.19±.04	0.29±.04	1.74	2.24	11
Sceloporus undulatus	0.20±.05	-	-	-	0.18±.04	0.03±.04	0.22±.30	-	-	-	-	-	0.01±.01	-	0.64	1.29	5
Urosaurus graciosus	-	-	-	-	-	-	-	-	0.03±.01	-	-	-	-	0.14±.02	0.17	0.47	2
Urosaurus ornatus	-	-	0.03±.02	-	0.03±.08	-	-	-	0.02±.01	-	-	0.28±.07	0.19±.02	-	0.55	1.15	5
Uta stansburiana	-	-	0.16±.02	0.17±.02	0.01±.01	0.04±.05	-	0.02±.02	0.25±.04	0.22±.06	0.08±.04	-	0.04±.02	0.08±.02	1.10	1.96	10
Eumeces g. arizonensis	-	-	0.10±.02	-	0.03±.03	0.05±.02	0.04±.05	-	-	-	-	0.03±.01	0.06±.02	0.02±.01	0.33	1.83	7
Eumeces obsoletus	-	-	-	-	0.01±.01	0.04±.06	-	-	-	-	-	-	0.03±.01	-	0.08	0.98	3
Cnemidophorus exsanguis	-	-	-	-	0.01±.01	-	-	-	-	-	-	-	-	-	0.01	0.00	1
Cnemidophorus tigris	0.03±.01	-	0.14±.02	0.23±.07	0.02±.04	0.08±.11	-	0.16±.22	0.32±.07	0.45±.01	0.35±.15	0.23±.06	0.11±.02	0.32±.05	2.44	2.25	12
Cnemidophorus velox	-	-	-	-	0.05±.04	-	0.03±.03	-	-	-	-	-	-	-	0.08	0.66	2
Xantusia v. arizonae	-	-	0.06±.02	-	0.01±.03	-	-	-	-	-	-	-	-	-	0.07	0.41	2
Xantusia v. vigilis	-	-	-	0.05±.02	-	-	-	-	-	-	-	-	-	-	0.05	0.00	1
RA	0.26±.03	0.63±.01	0.75±.01	0.75±.02	0.73±.03	0.42±.04	0.39±.05	0.64±.09	0.96±.04	0.99±.04	0.91±.12	0.73±.01	0.68±.02	0.85±.01			
Trap-nights	2	412	1608	1168	564	608	736	472	416	508	504	188	1270	260			
Species Diversity (H')	0.75	0.00	1.96	1.72	1.42	1.93	1.01	1.21	1.74	1.32	1.53	1.21	1.83	1.35			
Number of Species within an SHS			8	7	11	8	4	5	9	5	7	4	9	5			

TABLE 3 - Summary of Life Forms for lizards of the Hualapai-Aquarius planning units. Based on observations and Pianka (1966).

Diurnal Species

I. Widely foraging species . . . . . *Cnemidophorus* and *Eumeces*

II. Sit-and-wait species

(a) Under bushes and on large rocks, litter, trees, etc. . . . *Crotaphytus*, *Sceloporus*, *Urosaurus*, *Uta*

(b) Open spaces between shrubs
ab. Generalists . . . . . *Callisaurus*, *Cophosaurus*, *Gambelia*, and *Holbrookia*
bb. Specialists . . . . . *Phrynosoma*

III. Herbivorous

(a) (IIa-d) . . . . . *Dipsosaurus*
(b) (IIa) . . . . . *Sauromalus*

Nocturnal Species

I. Open foraging . . . . . *Coleonyx*

II. Fossorial-Boreal . . . . . *Xantusia*

Crepuscular

I. Olfaction and digging . . . . . *Heloderma*

Figure 2. Comparison of activity intensity between *Cnemidophorus tigris* and *Eumeces gilberti* for the months of April, May, and June, 1979. Populations were sympatric and activity was expressed as a percent of the total number of lizards observed during a given month. Means are illustrated ± SD.

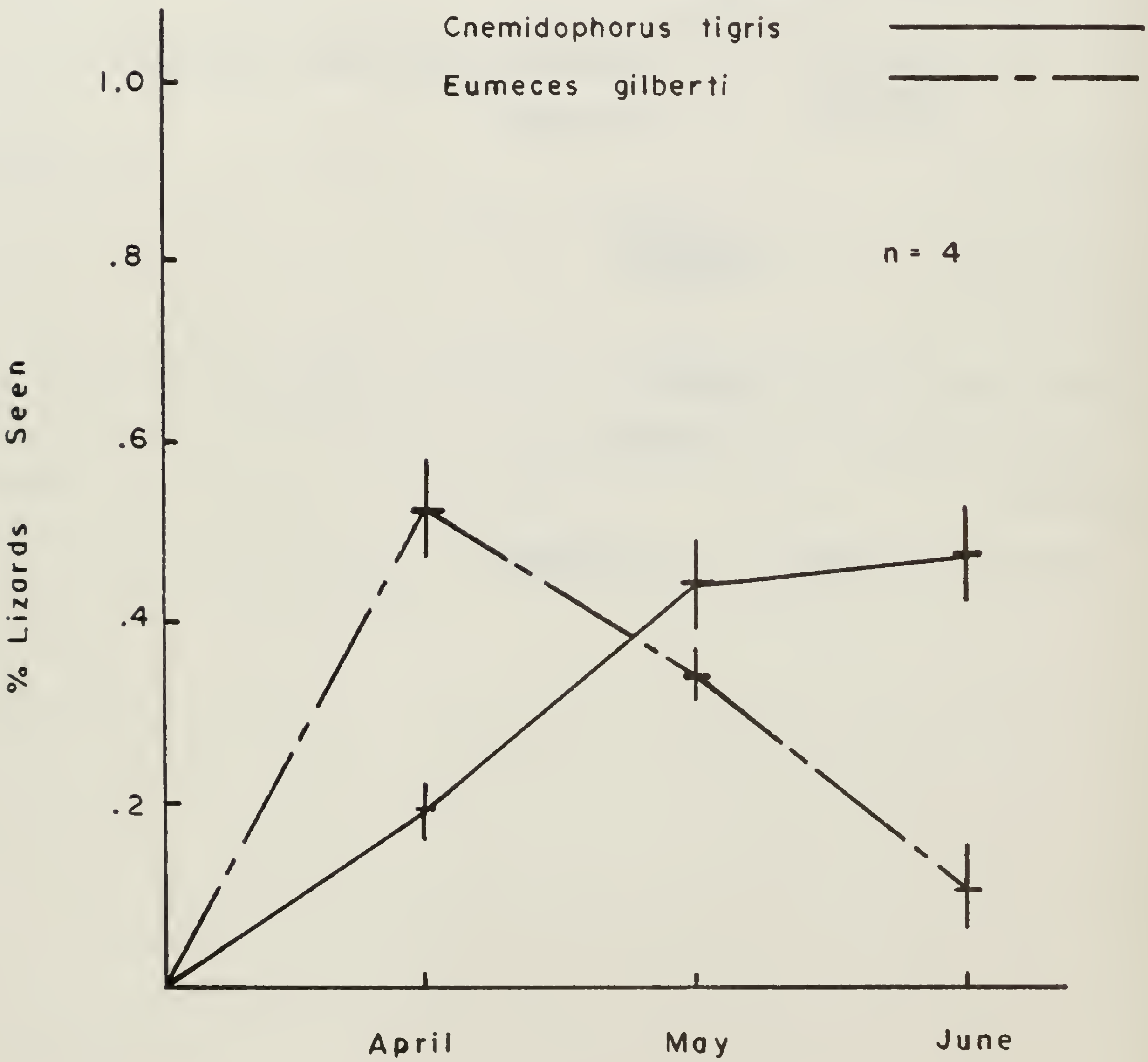
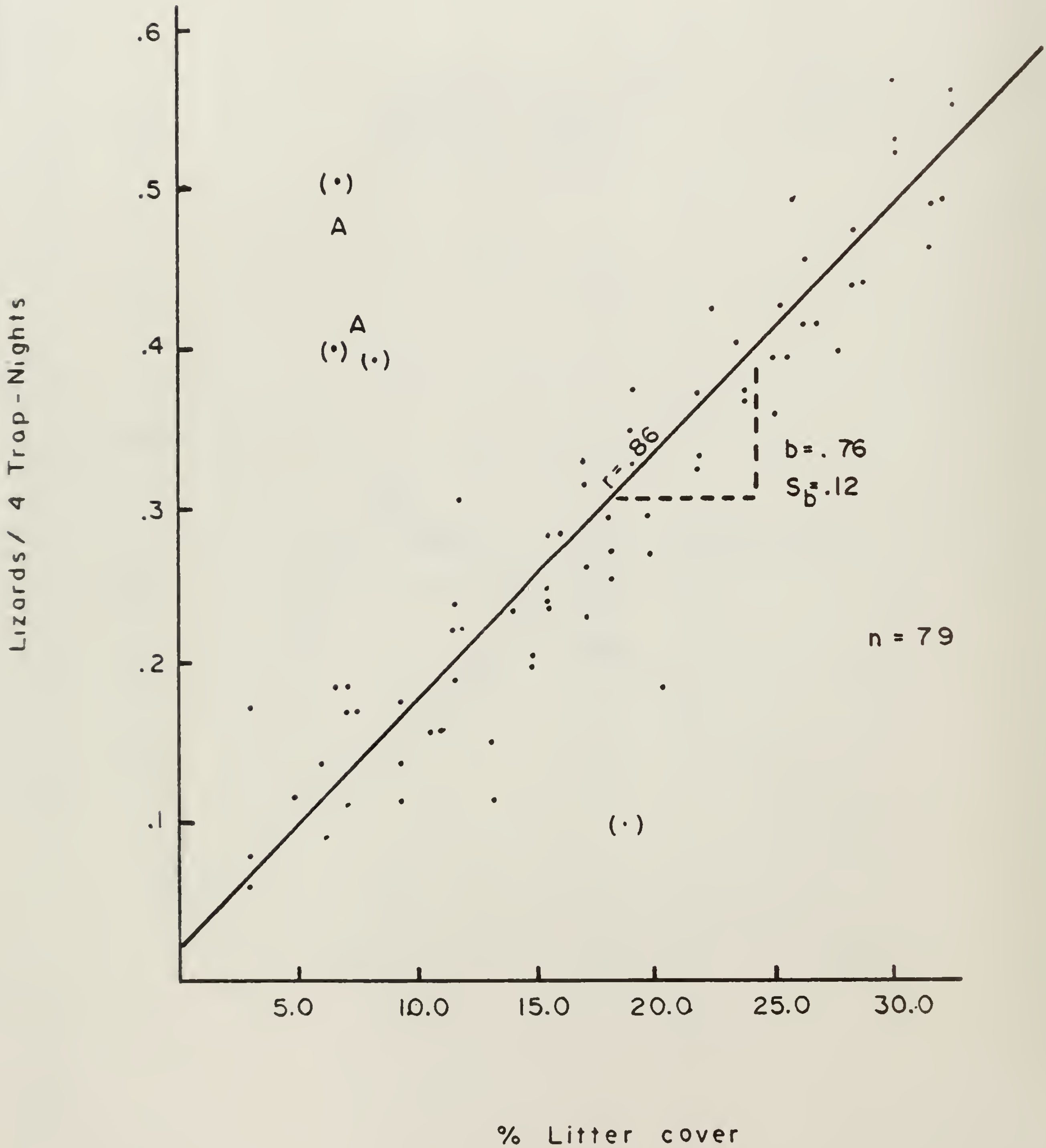


Table 4. Adult-juvenile and sex ratios of lizards trapped in Arrays. See Appendix 7 for standard habitat site abbreviations. M = male; F = female; JU = juvenile.

	FP		FA		PJ		JM		IC		OC		DG		JT		CB		SP		CM		CV		MD		MR	
	M:F	AD:JU	M:F	AD:JU	M:F	AD:JU	M:F	AD:JU	M:F	AD:JU	M:F	AD:JU	M:F	AD:JU	M:F	AD:JU	M:F	AD:JU	M:F	AD:JU	M:F	AD:JU	M:F	AD:JU	M:F	AD:JU	M:F	AD:JU
Coleonyx variegatus															1:0	1:0	1:3	4:0			1:0	1:0						
Heloderma suspectum																			0:1	0:1								
Callisaurus draconoides					1:3	2:3									8:4	6:6	2:0	2:0			1:0	1:0						
Cophosaurus texana			1:1	1:1			2:0	0:2															1:0	1:3				
Crotaphytus collaris											0:1	1:0	3:0	2:1														
Dipsosaurus dorsalis	NOT TRAPPED IN ANY ARRAYS																											
Gambelia wislizenii	NOT TRAPPED IN ANY ARRAYS																											
Phrynosoma douglassi	0:1	1:0	1:0	1:0	3:3	5:1					2:0	2:0																
Phrynosoma platyrhinos							0:1	1:0							1:0	1:0	5:2	7:0	4:1	6:0	8:3	8:3						
Phrynosoma solare																	1:0	1:0										
Sauromalus obesus					2:3	3:2															0:1	1:0						
Sceloporus magister					5:1	5:1	0:3	3:0	3:2	3:2	4:2	6:0			12:8	9:11	3:3	6:0	6:12	18:0	11:15	14:12	17:19	24:12	3:6	6:3	4:5	5:4
Sceloporus undulatus	7:6	4:9							15:10	14:12	1:0	2:0	5:10	11:14									1:0	1:0				
Urosaurus graciosus																	1:1	2:0							1:5	4:2		
Urosaurus ornatus					1:0	1:0			6:2	6:2							1:0	0:1					18:11	18:10			12:6	13:6
Uta stansburiana					4:0	3:0	7:4	8:3			1:2	3:0			5:1	5:1	6:5	11:0	5:3	8:2	3:4	6:1	4:3	6:1	3:2	2:1		
Eumeces gilberti arizonensis					3:2	3:2			3:0	3:0	4:1	5:0	2:0	2:0									3:0	3:0			0:1	1:0
Eumeces obsoletus									1:1	2:0	1:1	2:0											1:0	1:0				
Cnemidophorus exsanguis									0:4	1:3																		
Cnemidophorus tigris	1:0	0:1			5:3	6:3	9:12	14:10	0:5	3:2	4:1	5:0			14:4	13:5	13:7	18:2	28:22	50:1	11:22	24:10	9:10	16:6	7:4	9:3	1:4	4:1
Cnemidophorus velox									0:5	1:4			0:1	1:0														
Xantusia vigilis arizonae					1:1	2:0			1:1	1:1																		
Xantusia vigilis vigilis							0:1	1:0																				

Figure 3. Relationship between relative abundance of <u>Sceloporus</u> <u>magister</u> and downed vegetative litter (primarily tree limbs and trunks). Litter is expressed as the percentage of downed litter vs. the total ground, surface area. A = points significantly outside the deviation of the best fit line. These points also represent sample areas with buildups of Neotoma nests. Points indicated by A were not used in determining r.



typical of stable populations (Near 1:1, Tables 2 and 4). S. magister demonstrated population numbers for many areas that may indicate increasing trends (large number of juveniles). In areas of sympatry, S. magister activity preceded that of S. undulatus.

Crotaphytus collaris, a sit-and-wait forager while on rocks and litter, was abundant at SHSs dominated by large rocks and rock outcrops. Although not demonstrated by trap-night success (Table 2), field observations indicate C. collaris to thrive on rock-dominated malpais mesa tops (desert grassland). Similar to lizards increased by downed vegetative litter content, large amounts of rock make available numerous roosting and feeding sites to C. collaris, thus supporting greater numbers. Field observations reveal that C. collaris populations are either stable or, as in the case of desert grassland, increasing (based on large abundance of females in the populations).

Urosaurus ornatus, U. graciosus, and Uta stansburiana constitute the remainder of the sit-and-wait foragers while on rocks, trees, and litter (Table 3). These species were typically found at lower elevation SHSs and demonstrated high trap-night success (Table 2). U. ornatus and U. graciosus were sympatric on creosote bush SHSs (Table 2). Both persisted in areas where litter and rock were prevalent. U. stansburiana demonstrated a high diversity index, a result of a broad distribution throughout the study area (Table 2).

Sit-and-wait foragers of open spaces of the family Iguanidae were represented by the species Callisaurus draconoides, Cophosaurus texana, Gambelia wislizenii, (formally Crotaphytus), Phrynosoma douglassi, Phrynosoma platyrhinos, and P. solare.

Ecologically, C. draconoides and C. texana are similar. C. draconoides demonstrated higher trap-night success (0.32) than C. texana (0.12) (Table 2), probably resulting from C. texana occurring on the periphery of its distribution within our study area. These species were sympatic only at cottonwood-willow SHSs and demonstrated abundance and sex and adult-juvenile ratios indicative of stable populations (Tables 2 and 4).

Gambelia wislizenii, the largest of the predatory, open-space, sit and wait predators, was not trapped in any Arrays. Typically, these lizards are found in palo verde-saguaro SHSs where large rock and rugged gulleys predominate. G. wislizenii was verified by casual observation but was not statistically analyzed due to lack of trap-night data.

The genus Phrynosoma was represented by three species within the study area: the high elevation P. douglassi, moderate-to-low elevation P. platyrhinos, and low elevation P. solare (Table 2). The genus Phrynosoma comprise species that specialize in foraging ants, and are thus referred to as specialists (Table 3). Of the three species, P. platyrhinos had the highest trap-night success, 0.44/4TN (Table 2). A strong positive correlation (r= 0.88) was found between P. platyrhinos and P. douglassi abundance and the number of ant hills (Figure 4), further supporting existing data on this species as an ant specialist (to be discussed in the following section). P. platyrhinos is replaced by P. douglassi in habitats from pinyon-juniper and above (Table 2). P. solare was verified only in creosote bush SHSs (Table 2) but may occur in saguaro palo-verde communities. Populations of P. platyrhinos and P. douglassi appear to be increasing in many areas (Tables 2 and 4, based on near 1:1 adult-juvenile ratios). Insufficient data on P. solare prevent any population trend analysis.

The distribution of the herbivorous iguanid lizards Dipsosaurus dorsalis and Sauromalus obesus was related to specific features within SHSs. D. dorsalis, although not trapped, was observed in areas with high percentages of creosote bush (includes saguaro-palo-verde SHS). Creosote flowers may be an important dietary constituent for D. dorsalis. S. obesus demonstrated a preference for extremely rocky situations, especially in malpais areas.

Heloderma suspectum of the family Helodermatidae, was trapped only once within the study area. Several casual observations (n = 5) were combined into a distribution map appearing in Appendix 3. Separate transects comparing H. suspectum abundance with avian ground nests yielded a moderate correlation: r = 0.76 (Figure 5). The canotia mix SHS demonstrated the highest numbers of both ground nests and H. suspectum abundance. Although only one specimen was trapped, our field observations indicate H. suspectum populations to be stable within canotia mix standard habitat sites (high ratio of females and juveniles in the population).

Nocturnal lizards were represented by the species Coleonyx variegatus (Gekkonidae), Xantusia vigilis arizonae, and Xantusia vigilis vigilis (Xantusidae)(Table 2). C. variegatus had a low overall trap-night abundance, 0.09 (Table 2), occurring in areas of high rock and litter content. X. v. arizonae showed distribution restricted to pinyon-juniper and chaparral SHSs (Table 2). X. v. arizonae was larger (in size) than X. v. vigilis (highly associated with foothills and hillsides with high concentrations of Nolina bigelovi). Both X. v. arizonae and X. v. vigilis had limited activity periods and low trap-night success, X. v. arizonae with 0.07 and X. v. vigilis with 0.05, (Table 2).

C. tigris and S. magister had the highest habitat use diversities (HUDs) of lizards sampled, 2.25 and 2.24 respectively (Table 2). U. stansburiana and E. g. arizonensis also had high HUDs, but the latter was found only in Upper Sonoran and riparian SHSs (Table 2). H. suspectum, P. solare, C. exsanguis and X. v. vigilis had HUDs of 0.00 each occurring in only one SHS (Table 2).

Overall saurian trap-night success, based on months with the highest activity, was greatest in saguaro-palo verde SHSs, 0.99L/4TN (Table 2). Riparian areas demonstrated high trap-night abundance (Table 2,) whereas high elevation SHSs demonstrated generally low trap-night success (Table 2).

Figure 4. Relationship between *Phrynosoma platyrhinos* and *Phrynosoma douglassi* abundance and ant hill abundance. Lizard and ant hill abundance are expressed as the number seen per 4000 ft. transect.

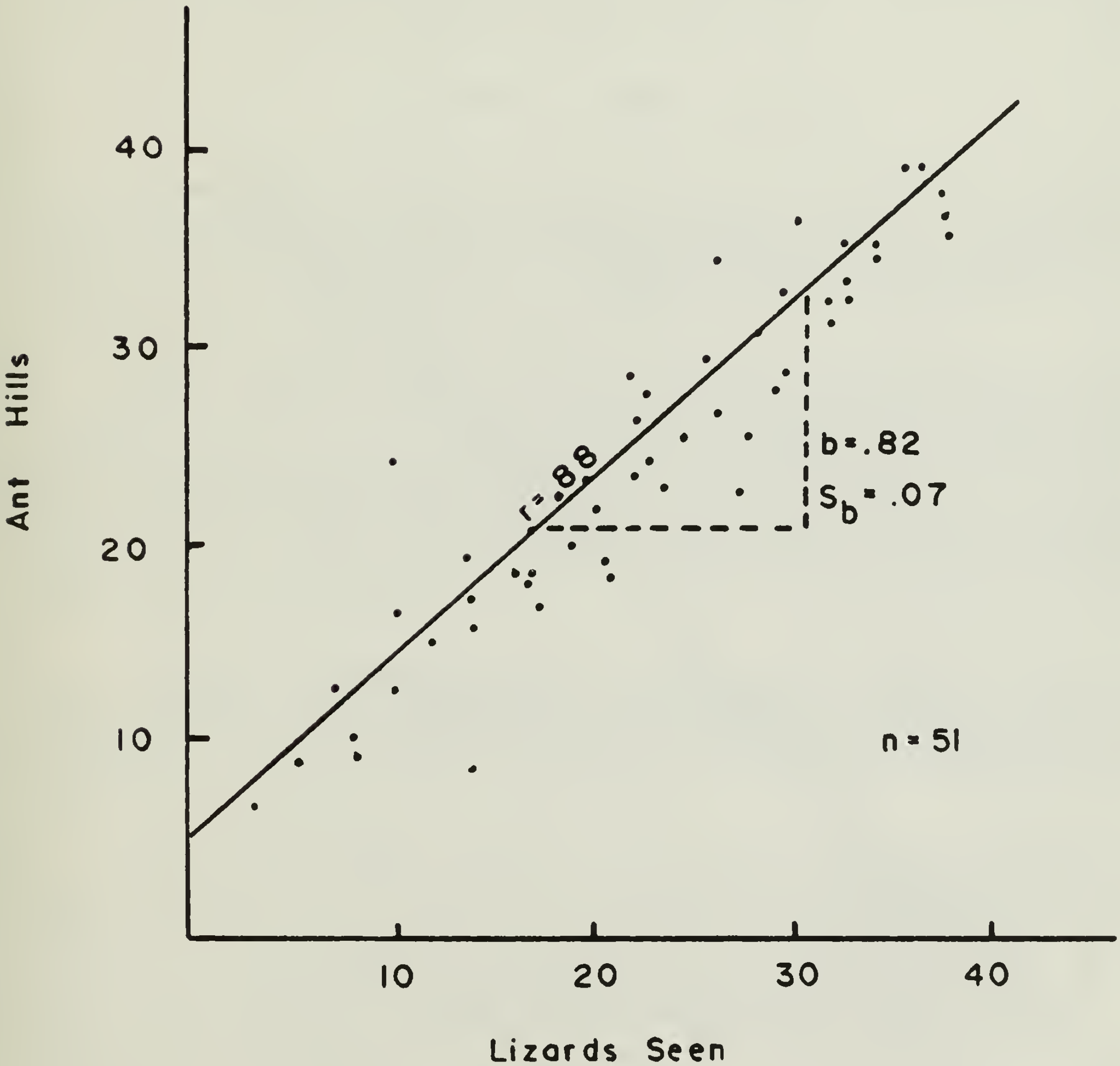
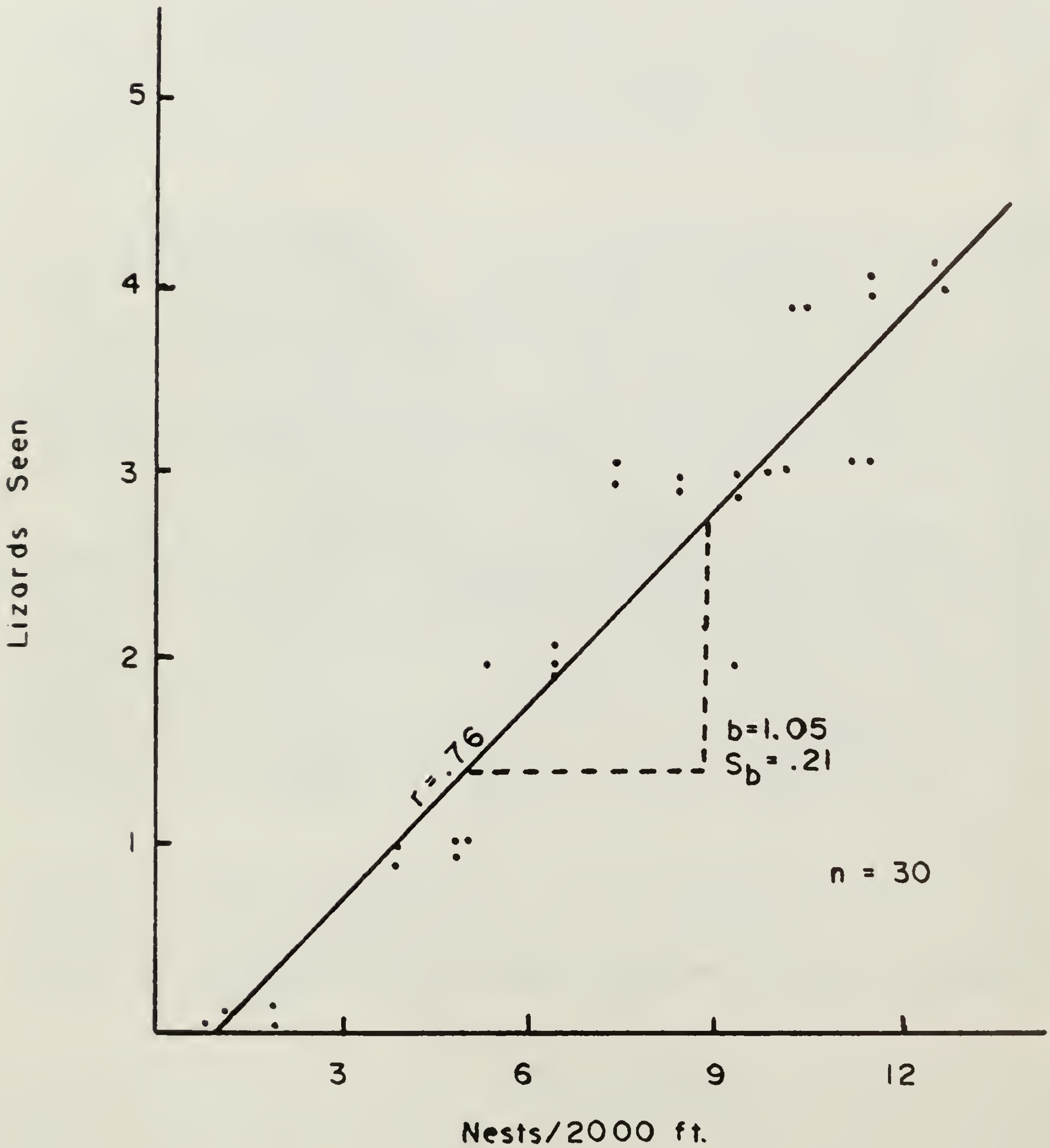


Figure 5. Relationship between Heloderma suspectum abundance and the number of avian ground nests, primarily quail and dove. Lizard and nest abundance are expressed as the number seen per 2000 ft. transect.



Pinyon-juniper and open chaparral had the greatest species diversities with each SHS consisting of 8 species (Table 2). Interior chaparral had the greatest number of species (11) but total abundance was dominated by a few species which resulted in only a moderate diversity index (1.42, Table 2). Juniper mixed-scrub, creosote bush, and cottonwood-willow SHSs all had indices greater than 1.70 (Table 2). Ponderosa-aspen, ponderosa pine, and desert grassland had the lowest diversity indices within the study area (Table 2). Only one species (Phrynosoma douglassi) was trapped in the ponderosa-aspen SHS (Table 2).

Degradation of condition in desert grassland SHSs would seem to reduce species richness of lizards (Table 5). Poor condition desert grassland sites demonstrated fewer species, lower abundance, and fewer stable populations than fair condition sites (Table 5).

REPTILIA - SERPENTES (OPHIDIA)

Of 26 species of snakes, Crotalus atrox (Crotalidae) was found to be the most abundant and evenly dispersed, 14.82 (Table 6), occurring in six of the fourteen SHSs (Table 6). C. atrox activity was intense in mid-April. Four den sites were verified on boulder-strewn hillsides where up to 15 adults were observed per visit.

Other members of the crotaline family with relatively high abundance and habitat use diversities were Crotalus scutulatus and Crotalus viridis cerberus (Table 6). C. scutulatus occurred sympatric to C. atrox, and C. v. cerberus occurred at upper elevation SHSs allopatric to all other crotalines with the exception of Crotalus molosus (Table 6). C. molossus was strictly related to rock outcrops and tallus slopes within chaparral SHSs (Table 6). One record, however, demonstrates the exploitation of rocky canotia mix SHSs.

Crotalus cerastes and Crotalus mitchelli make up the remainder of the genus Crotalus in our study area. C. cerastes was limited in distribution to sandy soils within creosote bush flats near Yucca, Arizona (Appendix 3). C. mitchelli is ecologically similar to C. molossus, with the exception of the latter exploiting higher elevations.

The colubrid family had by far the largest number of representatives within the study area (Table 6). Of the colubrids, Masticophis was the most represented genus (Table 6). Masticophis flagellum had the third highest HUD, 1.56 (Table 6), occurring in many low-to-mid elevation SHSs (Table 6). Masticophis taeniatus replaced M. flagellum at higher elevations (Table 6), demonstrating a moderate HUD, 1.48 (Table 6). Masticophis bilineatus occurred sporadically throughout Lower and Upper Sonoran Life Zones (Table 6), with highest abundance along Burro and Francis creeks. Of the colubrid snakes, Salvadora hexalepis had the highest HUD, 1.88, occurring in a variety of habitats in high abundance (Table 6). This species is ecologically similar to M. flagellum (fast-moving, diurnal, lizard-eater). See Table 7 for ecological life-forms of each snake.

TABLE 5 - Plant species compositon and lizard relative abundance for two condition classes of mesa top, desert grassland standard habitat sites. Means are listed ± one standard deviation.

Plant Species	Nelson Mesa (Poor Condition)**	Bozarth Mesa (Fair Condition) Composition %
Hilaria mutica	2.1 ± 2.4	14.7 ± 1.6
Aristida sp.	1.1 ± 0.9	3.7 ± 2.0
Acacia greggii	2.7 ± 1.1	1.6 ± 1.1
Gutierrezia sp.	90.1 ± 1.7	73.3 ± 3.8
Quercus turbinella	1.7 ± 0.8	(T)
Eriogonum wrightii	1.9 ± 1.3	9.4 ± 2.6
% Cover (Perennial)	16.3 ± 2.6	23.4 ± 3.2
*Total Lizard Abundance/4TN	0.07 ± 0.01	0.25 ± 0.03
No. of Lizard Species	2	3
No. of Gravid Females	-	4
Adult-Juvenile Ratios	5:0	11:4
No. of Species in Decline	1	-
No. Species Stable	1	1
No. Species Increasing	-	2

* Student T-test on the means of total lizard abundance at $p = 0.025$ showed significant difference between Nelson and Bozarth Mesas.

** Condition classes are based on methods of the Soil Conservation Service (1976).

TABLE 6 - Relative abundance (RA), species diversity (H'), and habitat use diversity (HUD') of 25 species of snakes in 14 standard habitat sites. RA = n_i/N (100). $H' = -\sum_{i=1}^{s} p_i (\log p_i)$ (Orr et al 1973), where s = number of species and p_i = proportion of the total number of individuals consisting of the i^{th} species. HUD' = H' except s = number of standard habitat sites and p_i = the proportion of the total number of individuals occurring in the i^{th} standard habitat site. N = total number of snakes. n_i = total number of a given species. n' = total number of snakes for a given standard habitat site. n = total number of species in a given standard habitat site. NS = number of standard habitat sites a species occurred in. See Appendix 7 for standard habitat site abbreviations.

Species	PP	PA	PJ	JM	IC	OC	DG	JT	CR	SP	CM	MR	CW	HR	NS	HUD'	n_i	RA
Lichanura trivirgata	----	----	----	----	----	----	----	----	----	0.78 (1)	0.78 (1)	----	----	----	2	0.70	2	1.56
Arizona elegans	----	----	0.78 (1)	----	----	----	0.78 (1)	----	----	0.78 (1)	2.34 (3)	----	----	----	4	1.25	6	4.68
Diadophis punctatus	----	----	----	0.78 (1)	----	----	----	----	----	----	----	----	----	----	1	0.00	1	0.78
Hypsiglena torquata	----	----	0.78 (1)	----	----	----	----	----	----	----	----	----	----	----	1	0.00	1	0.78
Lampropeltis getulus	----	----	0.78 (1)	----	----	----	----	----	----	----	----	0.78 (1)	----	----	2	0.70	2	1.56
Lampropeltis pyromelana	1.56 (2)	----	----	----	----	----	----	----	----	----	----	----	----	----	1	0.00	2	1.56
Masticophis bilineatus	----	----	----	----	1.56 (2)	----	1.56 (2)	----	----	0.78 (1)	----	----	----	0.78 (1)	4	1.34	6	4.68
Masticophis flagellum	----	----	----	2.34 (3)	----	----	----	0.78 (1)	2.34 (3)	2.34 (3)	1.56 (2)	----	----	----	5	1.56	12	9.36
Masticophis taeniatus	0.78 (1)	----	0.78 (1)	0.78 (1)	2.34 (3)	----	----	----	----	----	----	----	----	0.78 (1)	5	1.48	7	5.46
Phyllorhynchus decurtatus	----	----	----	----	----	----	----	----	----	1.56 (2)	----	0.78 (1)	----	----	2	0.64	3	2.34
Pituophis melanoleucus	----	----	----	----	1.56 (2)	----	----	1.56 (2)	----	1.56 (2)	4.69 (6)	0.78 (1)	----	----	5	1.43	13	10.15
Rhinocheilus lecontei	----	----	0.78 (1)	----	----	----	----	----	----	0.78 (1)	0.78 (1)	----	----	----	3	1.11	3	2.34
Salvadora hexalepis	----	----	----	1.56 (2)	0.78 (1)	----	----	1.56 (2)	----	2.34 (3)	1.56 (2)	0.78 (1)	0.78 (1)	----	7	1.88	12	9.36
Sonora semiannulata	----	----	----	2.34 (3)	----	----	0.78 (1)	----	----	3.13 (4)	----	----	----	----	3	0.98	8	6.25
Tantilla g. atriceps	----	----	----	----	----	----	----	----	----	----	----	----	0.78 (1)	----	1	0.00	1	0.78
Thamnophis cyrtopsis	----	----	----	----	----	----	----	----	----	----	----	----	3.90 (5)	----	1	0.00	5	3.90
Thamnophis marcianus	----	----	----	----	----	----	----	----	----	----	----	----	----	0.78 (1)	1	0.00	1	0.78
Trimorphodon b. lambda	----	----	----	----	----	----	----	----	----	0.78 (1)	----	----	----	----	1	0.00	1	0.78
Crotalus atrox	----	----	----	1.56 (2)	1.56 (2)	----	----	3.90 (5)	2.34 (3)	3.90 (5)	----	1.56 (2)	----	----	6	1.71	19	14.82
Crotalus mitchelli	----	----	----	0.78 (1)	----	----	----	----	----	----	----	----	0.78 (1)	----	2	0.70	2	1.56
Crotalus molossus	----	----	----	----	0.78 (1)	----	----	----	----	----	----	----	----	----	1	0.00	1	0.78
Crotalus scutulatus	----	----	0.78 (1)	----	----	----	----	3.13 (4)	0.78 (1)	1.56 (2)	0.78 (1)	----	----	----	5	1.41	9	7.03
Crotalus v. cerberus	0.78 (1)	----	----	----	2.34 (3)	----	0.78 (1)	----	----	----	----	----	----	----	3	0.95	5	3.90
Micruroides euryxanthus	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.56 (2)	-----	-----	1	0.00	2	1.56
Leptotyphlops humilis	----	----	1.56 (2)	----	----	----	----	----	----	1.56 (2)	----	----	----	----	2	0.70	4	3.13
H'	1.05	0.00	1.91	1.86	1.80	0.00	1.33	1.40	1.00	2.43	1.71	1.74	1.25	0.70				
n'	4	0	8	13	14	0	5	14	7	28	16	8	9	2				
n	3	0	[illegible]	7	7	0	4	5	3	13	[illegible]	6	5	2				
RA	3.12	0.00	6.24	10.16	10.94	0.00	3.90	10.93	5.46	21.85	12.49	6.24	7.02	1.56				

N = 128

TABLE 7 - Life-forms of snakes of the Hualapai and Aquarius Planning Units.

Diurnal	
I. Surfacorial - Lizard foragers.......	*Masticophis flagellum* *Masticophis bilineatus* *Masticophis taeniatus* *Salvadora hexalepis*
Nocturnal	
I. Fossorial..........................	*Hypsiglena torquata* *Phyllorhynchus decurtatus* *Sonora semiannulata* *Tantilla p. atriceps* *Micruroides euryxanthus* *Leptotyphlops humilis*
II. Surfacorial........................	*Arizona elegans* *Rhinocheilus leconti*
III. Arboreal..........................	*Lichanura t. gracia* *Trimorphodon b. lambda*
Crepuscular	
I. Aquatic............................	*Thamnophis cyrotopsis* *Thamnophis marcianus*
II. Fossorial..........................	*Diadophis punctatus* *Lampropeltis pyromelana*
III. Surfacorial........................	*Lampropeltis getulus* *Pituophis melanoleucus* *Crotalus atrox* *Crotalus cerastes* *Crotalus molossus* *Crotalus scutulatus* *Crotalus v. cerberus*

Nocturnal colubrids were well represented throughout the study area. Sonora semianulata and Rhinocheilus leconti were the most common (Table 6), with the fossorial-surfacoreal (refers to species that spend most of their time under litter on the surface or underground) Tantilla planceps atriceps, Hypsiglena torquata, Diadophis punctatus, and Phyllorhynchus decurtatus the least common (Table 6). The rock-restricted, arboreal, Trimorphodon biscutatus lambda was also an uncommon snake, and possessed a low HUD, 0.00 (Table 6).

Crepuscular colubrids were represented by the species Lampropeltis getulus, Lampropeltis pyromelana, Thamnophis cyrtopsis, and Thamnophis marcianus (Table 6).

L. getulus and L. pyromelana exploited entirely different habitats (Table 6). L. getulus was found in low elevation, xeric habitats with varying amounts of water, and L. pyromelana was found specifically in higher, mesic elevations of the Hualapai Mountains near perennial water. Whereas L. getulus was abundant in certain areas, L. pyromelana was never abundant (Table 6).

T. cyrtopsis and T. marcianus were found only at SHSs with intermittent or permanent water (riparian SHS or at spring sites within other SHSs). T. cyrtopsis was extremely common along drainages of the Big Sandy and Santa Maria rivers and Burro and Francis creeks, where they feed primarily on Bufo and Hyla tadpoles. This species also occurred at isolated spring sites and dirt tanks in the Hualapai Mountains. Only one record of T. marcianus was obtained (the Big Sandy River).

One of Arizona's most unusual vertebrate species was verified during this study, Lichanura trivirigata gracia, a member of the world's most primitive snake family Boiidae. L. t. gracia populations occurred in areas with large boulders and rocky hillsides of the saguaro palo-verde and juniper mix SHSs (Table 6). Low elevation populations generally occurred near perennial or intermittent floodplains.

The family Leptotyphlopidae was represented by one species, Leptotyphlops humilis, which was fairly abundant in saguaro palo-verde SHSs (Table 6) where sand-bottom floodplains persisted.

The neurotoxic family Elapidae (primarily from tropical Africa and Asia) was represented by the species Micruroides euryxanthus. Existing on the periphery of its range in our study area, M. euryxanthus was quite rare.

The saguaro palo-verde SHSs had the highest combined ophidian diversity index (Table 6). Pinyon-juniper, juniper mix, interior chaparral, and cottonwood-willow riparian SHSs all had indices greater than 1.25 (Table 6). Of the SHSs sampled, ponderosa-aspen had the lowest ophidian diversity index, 0.00 (Table 6).

DISCUSSION

AMPHIBIA

My studies reveal that members of the families Bufonidae, Hyliidae, Pelobatidae and Ranidae are restricted to aquatic and semi-aquatic situations, often independent of habitat type. The dependence of these species on water varies, and is related to specific physiological, morphological, and behavioral adaptations.

Of the amphibians, Rana pipiens was perhaps the most dependent on permanent water, individuals exclusively associated with perennial drainages and springs. Studies by Walker and Whitford (1970) showed R. pipiens to have the lowest skin absorption abilities when compared to species of Scaphiopus and Bufo. Its inability to absorb soil moisture efficiently may prevent R. pipiens from exploiting more xeric habitat.

Hyla arenicolor, similar to R. pipiens, was associated with perennial streams and springs, but not exclusively. As perennial streams recede during warm summer months, tadpoles migrate into remaining pools. Ford and Breed (1970) demonstrated nest-building by H. arenicolor tadpoles confined to small pools. Nest-building is adaptive because it decreases evaporative water loss through reduction of exposed surface area, thus extending tadpole survival. H. arenicolor exploit areas with intermittent waterflow by using rugged, narrow canyons, which facilitate more mesic conditions. Adults were observed in crevices along vertical rock walls where heat stress may be reduced.

The bufonid and pelobatid toads are among the best adapted Anurans to terrestrial life. Of these, Bufo woodhousei seems to be least adapted to terrestrial existence. Axtell (1963) and Bragg (1958) concluded that B. woodhousei distribution was related to moist, sandy river drainages at the western margin of its range where this species avoids midday desiccation by burrowing into loose soil. My records support these findings.

Bufo punctatus and Bufo microscaphus have adapted behaviors that result in exploitation of terrestrial SHSs transected by intermittent and permanent waterflow. These adaptations account for high abundance and habitat use diversity figures obtained in this study. Similar to H. arenicolor, B. punctatus constructs nests that reduce evaporative water loss, thus extending tadpole survival. Studies by Weintraub (1974) demonstrated adult B. punctatus to migrate in response to receding surface water. Migration was always in the direction of increased water availability. Weintraub (1974) also demonstrated migration of adult B. punctatus away from pools during extended wet periods, attributing to high mortality during following dry periods. Adults remaining in floodplains were able to home back to original areas of inhabitance.

Ecologically, B. microscaphus are similar to B. punctatus, inhabiting both high and low elevation washes. Unlike B. punctatus, B. microscaphus depends on excavating its own burrows (Jones unpl. data), especially in the sand bottoms of Knight Creek and the Big Sandy River. Sympatric B. punctatus used rock and litter cover sites, thus reducing competition with B. microscaphus at lower elevations. In upland drainages these species are mostly allopatric, a result of few drainages having both sand and rocky substrate (typical of areas in the Hualapai Mountains). B. microscaphus exploit dirt tanks and upland areas of sandy or loose soil.

Subspecific difference in populations of B. microscaphus may occur in the study area. Shannon and Lowe (1955) described B. m. mexicanus as upland subspecies distinct from the lower elevation B. m. microscaphus. High elevation B. microscaphus in our study area were lighter and more dorsally blotched than lower elevation populations. My data are inconclusive as to whether both subspecies inhabit the area.

Knowledge of Bufo alvarius is limited to one locality record. Studies in the previous ES area - Black Canyon-Skull Valley Planning Units of central Arizona demonstrated B. alvarius to exploit springs and dirt tanks (Jones unpl.data). Cole (1962) concluded that B. alvarius was very rare at the edges of its distribution, the case with the southern portion of our study area. This explains low abundance and habitat use diversity obtained for this species during my studies.

Previous studies have shown Scaphiopus couchi to be highly adapted to terrestrial existence. Clanahan (1967) demonstrated several adaptive physiological mechanisms allowing a 10-month burrowing phase: body fluid concentration up to 600mOsm/l of 50% urine, storage of fat and metabolic utilization during inactivity, and utilization of dilute urine in maintaining body fluids. Walker and Whitford (1970) demonstrated abilities of this species to absorb soil moisture up to 2.5 atmospheres (double that of many anurans), further facilitating extended fossorial existence. Developing larvae of S. couchi are also adapted to terrestrial existence as they possess high tolerance to heat (Justus et al. 1977). However, this species seems limited to areas with deep sand bottoms which may partially account for a low habitat use diversity (few SHSs with deep sand).

S. couchi keys on ground rumbling created by thunderstorms for emergence during warm summer months (Bondello and Brattstrom 1979). Thunderstorm rumbling is an indicator to S. couchi of accumulation of surface water necessary for breeding. Artificial ground rumbling (sonic booms and ORV races) result in surfacing of S. couchi at times when there is no surface water, thus causing desiccation and some mortality of individuals (Bondello and Brattstrom 1979).

Ambystoma tigrinum (the only caudate in our area) distribution is probably a result of introduction by man. On several occasions in New Mexico and Arizona subspecies of A. tigrinum have been observed in a single pond (Whitford pers. comm.). Ranchers further indicate that this species was introduced into the Hualapai-Aquarius Planning Units. So called "water dogs" have been released into dirt tanks and drinking troughs.

Webb and Roueche (1971) have determined that A. tigrinum use dirt tanks at higher elevations. Larval and neonate A. tigrinum depend on these sites and have evolved higher temperature tolerance than adults in adapting to warmer summer temperatures (Delson and Whitford 1973). Larvae and neonates can also follow O_2 and temperature gradients, allowing for movement into preferred temperature and O_2 regimes during different times of the day (Whitford and Massey 1970). Adult A. tigrinum can migrate great distances, using Neotoma dens and ground squirrel nests as cover sites during migration (Hamilton 1946).

Habitat management plans for amphibians of the Hualapai-Aquarius Planning Units should stress preservation of aquatic areas. Surface disturbance of aquatic areas including drainages and dirt tanks, by cattle and construction should be kept to a minimum during reproductive periods of May-July to reduce trampling of areas with deposited eggs.

Habitat improvement should consist of constructing retaining walls in drainages to facilitate water catchment. This improvement should improve reproduction of H. arenicolor, B. punctatus, and B. microscaphus, especially in drier years.

Areas inhabited by S. couchi can be maintained by restricting ORV use and mineral exploration. Natural catchments that increase surface water retention during summer rains will help perpetuate this species as well as B. woodhousei.

The Hualapai-Aquarius Planning Units have sufficient drainages to maintain healthy populations of B. punctatus and B. microscaphus. Because these species partition cover sites, habitat quality (particularly erosion) should be monitored where they are sympatric.

Maintenance of defined shorelines and detrital bottoms in dirt tanks should continue the existence of A. tigrinum in the two planning units.

No habitat management suggestions are recommended for B. alvarius or R. pipiens, with the exception of monitoring water quality at aquatic sites.

REPTILIA - CHELONIA

Gopherus aggassizi is being studied by Betty L. Burge and thus, is not extensively discussed in this paper. My study, however, has uncovered a high number of desert tortoises in a Joshua tree community on the west side of the Hualapai Mountains. These findings contradict Burge's (1979) conclusion that only populations north and west of the Colorado River occur in Joshua tree habitat.

The other genus of turtle, Kinosternon, has received little attention, especially in our area. Iverson (1978) refutes a record of Kinosternon flavescens by Stebbins (1966) along the Big Sandy River. Examination of this specimen indicated the Big Sandy record to be Kinosternon sonoriense. Our records support Stebbins (1966) but also verify the existence of K. sonoriense in the Big Sandy River. The canal in which both species were found was not typical of areas previously observed with K. sonoriense. Sites usually consist of rocky streambeds with limited amounts of silt (little or no rock occurred in the backwater canals of the Big Sandy). One consistent factor of the Big Sandy River and rocky streambeds is the buildup and maintenance of algae on water and substrate surfaces. Hulse (1974) observed similar algae buildup in creeks south of the Prescott National Forest, which he felt reduced evaporative water loss. Algae buildup may also reduce predation on K. sonoriense (allowing rapid escape) by reducing visibility, and help maintain temperatures within a cool preferred range during hot months.

K. flavescens has been reported primarily from sandy river drainages (Iverson 1978). The Big Sandy River provides this distributional requirement.

Habitat management for both of these species of turtles should include protection of riparian areas (especially the Big Sandy and Santa Maria rivers, and rocky perennial streams in the Bagdad area), maintenance of water quality standards and, any means of enhancing riparian habitat quality. Tadpole and fish populations are important to maintain as food sources for Kinosternon.

REPTILIA - SQUAMATA - (LACERTILIA) SAURIA

Of the reptiles, lizards are probably the best indicators of habitat quality, a result of utilizing and requiring specific habitat structures (Pianka 1966). Specific habitat requirements result from resource partitioning that reduces ecological competition among lizards. In addition to partitioning physical resources, lizards have adopted differential activity periods that reduce competition (Creusere and Whitford 1979).

Pianka (1966) separated lizards into life forms based on foraging and substrate requirements. We further separate lizards based on additional ecological information (Table 3).

DIURNAL

Widely Foraging

Of the widely foraging species, Eumeces gilberti arizonensis and Eumeces obsoletus require the most specialized habitat. Both species require moist, rocky situations where low-height vegetation prevails. Similar habitat requirements have been described for E. obsoletus throughout most of its range (Fitch 1955). Mesic situations in our area are provided by interior and open chaparral, pinyon-juniper, desert grassland, mixed broadleaf riparian, and cottonwood-willow riparian SHSs. Because E. g. arizonensis occurs in even abundance throughout these SHSs, it possesses a relatively high habitat use diversity (HUD). However, populations are generally decreasing except in pinyon-juniper SHSs. Areas with decreasing populations are overgrazed, possessing few low-height perennials (with the exception of snakeweed). Reducing such vegetation may reduce invertebrate food available to these species (invertebrates) and thus reduce their fitness (Whitford pers. comm.) Jones (1979b, 1981a) demonstrated lower abundance of Eumeces in overgrazed areas than in non-grazed areas, attributing decreased numbers and fitness to the loss of low-height perennial vegetation. Fitch (1955) discussed a relationship similar to that discussed by Jones in the species E. obsoletus. Fitch (1955) also demonstrated small home and foraging ranges that would further reduce fitness of this species in overgrazed situations. E. g. arizonensis and E. obsoletus do not lay eggs every year resulting in low recruitment and further reduction of the fitness of these species in overgrazed situations (Fitch 1955).

E. g. arizonensis and E. obsoletus have adapted burrowing behavior and limited activity patterns for exploitation of desert habitats (Fitch 1955). Morphologically, Eumeces is well equipped for burrowing, having reduced lateral posterior appendages, reduced eyes, and a snakelike body (Fitch 1955). Even with these adaptations, Eumeces is restricted to more mesic habitat types.

Establishing separate activity periods from that of C. tigris in areas of sympatry help E. g. arizonensis reduce competition for food, cover sites, territory, and reproductive sites. Creusere and Whitford (1979) demonstrated different activity periods in Chihuahuan lizards reduced competition for roosting, reproductive, and feeding sites. Activity periods of C. tigris and E. g. arizonensis also reflect the mean preferred body temperatures of these two species. Brattstrom (1965) determined mean preferred temperature of E. obsoletus to be between 31-34 C, a temperature range indicative of an animal active in late winter and early spring. No data are available on the preferred temperature of E. g. arizonensis, although it should be similar to that of E. obsoletus.

Populations of E. obsoletus may spread into more xeric habitats during wet years within our area as demonstrated by Whitford and Creusere (1977). Such migration may allow for intraspecific genetic exchange of populations of E. obsoletus which are separated by xeric habitat.

The genus Cnemidophorus demonstrated a distribution related to elevation. Cnemidophorus tigris inhabited all low elevation SHSs, reaching elevations up into ponderosa pine SHSs, thus possessing a high habitat use diversity. At higher elevations C. tigris numbers decreased probably resulting from competition with the ecologically similar Cnemidophorus velox and Cnemidophorus exsanguis. Medica (1961) studied four species of whiptails in New Mexico. He found results similar to mine: C. exsanguis prefer more mesic habitats than C. tigris. Because C. exsanguis and C.

velox are limited to the Upper Sonoran Life-zone, they possess low habitat use diversities. Medica also demonstrated differences in food consumption between C. tigris and C. exsanguis: C. tigris consuming smaller percentages of Hymenoptera and Orthoptera than C. exsanguis. Upper Sonoran standard habitat sites may support larger percentages of prey items preferred by C. exsanguis than C. tigris, thus reducing the fitness of C. tigris, especially in view of the similarity in the ecology of these two species of lizards.

Cnemidophorus species in our study area reproduce similarly except for C. exsanguis, which lay only one clutch per year. C. tigris and C. velox lay two or more clutches per year (Schall 1978; Medica 1967; Parker 1972).

Parker (1972) determined thermoregulation and preferred body temperature of Cnemidophorus and found no differences in either behavior nor preferred body temperature among the species.

The exploitation of high elevation SHSs has been treated by Asplund (1974). Asplund contends that larger whiptails can exploit cooler, more patchy environments than smaller lizards. His hypothesis supports the exploitation of chaparral SHSs in our study area by all three whiptails.

Sit-and-Wait Foragers - Trees, Rocks, Litter

High abundance of sit-and-wait foragers of this variety seem to be related to the availability of rock and litter. The second most abundant lizard, Sceloporus magister, demonstrated high correlation to the amount of downed vegetative litter, except in areas with high densities of pack rat dens. High abundance of S. magister in areas of high Neotoma nest density has been described by Parker and Pianka (1973), which explains S. magister abundance in areas of small amounts of downed litter.

Adult S. magister use both trees and downed litter whereas young use mostly downed litter and rocks (Vitt and Ohmart 1974). Vitt and Ohmart (1974) hypothesized young S. magister use downed litter and rock to reduce competition for roosting sites and prey with the arboreal Urosaurus graciosus and Urosaurus ornatus. Unlike young S. magister, adults can use both large and small prey, thus reducing competition with U. graciosus and U. ornatus on arboreal sites. Similar studies by Simon (1976) on Sceloporus jarrovi demonstrated capabilities of adults to use both large and small prey items whereas juveniles use only small prey items.

S. magister was replaced by Sceloporus undulatus at high elevation SHSs, but no other studies have treated a similar ecological situation. Tinkle (1976) studied sympatric populations of S. magister and S. undulatus and found little difference in their ecology. Differences in food consumed and thermoregulatory capacities may explain this elevational relationship. Toliver and Jennings (1975) showed S. undulatus to consume high percentages of Isoptera, Hymenoptera and Coleoptera and similar to Vitt and Ohmart's (1974) studies on S. magister, found S. undulatus to be an opportunistic forager, diets of the two species reflecting prey availability. Brattstrom (1965) demonstrated S. undulatus to possess lower preferred body temperatures than S. magister. Lower preferred temperature ranges of S. undulatus may allow this species to exploit higher elevations and prevent exploitation of low elevation SHSs. Conversely, higher preferred temperatures of S. magister allow this species to exploit hot, low-lying elevations but also prevent extensive exploitation of higher elevations. Because S. magister exploits both Upper and Lower Sonoran SHSs to some degree, it has a high habitat use diversity.

Similar to S. magister, S. undulatus preferred areas of high litter density, as demonstrated by its high abundance at ponderosa pine SHSs, which have high concentrations of downed litter. Downed litter increases the number of roosting, reproductive, and feeding sites available to S. undulatus in an area and, therefore, permits the area to support more lizards.

U. graciosus and U. ornatus were sympatric only at creosote bush SHSs. Vitt and Ohmart (1974) demonstrated sympatric populations of U. graciosus and U. ornatus in mesquite habitat. U. graciosus were more associated with mesquite drainages. Ironwood-blue palo verde habitat is limited to southern portions of the study area along Alamo Lake. Although Vitt and Ohmart (1974) suggest these species are exclusively arboreal, my findings expand habitat preference to include rocky surfacoreal situations within saguaro-palo-verde and creosote bush SHSs.

Crotaphytus collaris, the largest of the sit-and-wait predators, were common in rocky areas, generally independent of habitat type. Fitch (1956) reviewed the ecology of C. collaris and found a similar dependence on rocky habitat. He also found C. collaris to have a high preferred deep body temperature range (37-40 C.). Dawson and Templeton (1963) demonstrated similar temperature ranges for this species, as well as abilities to reduce heart rates and O_2 consumption when exposed to temperatures above 40C. They also found that C. collaris dissipates heat through evaporative cooling (panting). High preferred body temperature with physiological and behavioral mechanisms have allowed C. collaris to exploit rocky, low and middle elevation habitats. The build-up of huge populations of C. collaris on desert grassland SHSs within the study area results from large amounts of rocky, boulder strewn surfaces.

Sit-and-Wait Foragers - Open Spaces

Generalists

Callisaurus draconoides and Cophosaurus texana were found to have similar ecologies but demonstrated sympatry only at cottonwood-willow SHSs. Pianka and Parker (1972) discussed the ecology of C. draconoides in several areas. Generally, C. draconoides preferred Orthoptera and Coleoptera and possessed longer forelegs (expressed as percentages of snout-vent length) than eight other sympatric species. Pianka and Parker (1972) hypothesized that longer forelegs were related to the lizard's open-space feeding habits. Open-space feeding habits are also facilitated by high preferred body temperatures--39.6 C (Brattstrom 1965). C. draconoides has also demonstrated an ability to regulate body temperature through use of various body postures (Muth 1977). Muth (1977) concluded that convectional heat loss through elevated body postures allowed C. draconoides to maintain preferred body temperatures over long periods of time. The previously described adaptations have allowed C. draconoides to exploit hot, xeric environments.

Pianka and Parker (1972) stated that species of the genus Holbrookia which at the time included Cophosaurus, were ecologically similar to Callisaurus (high population turnover, short longevity). Neither Pianka and Parker (1972) nor Muth (1977), however, discussed any ecological differences between C. draconoides and C. texana that explain my observed differences in distribution. Food preference and thermoregulatory adaptation differences between the two species may explain some distributional observations, but lack of information prevents verifying such an explanation.

Gambelia wislizenii is more dependent on other lizards as food than any of the open-space, sit-and-wait foragers (Stebbins 1966; Tanner and Krough 1975). G. wislizeni has adapted dorsal pattern polymorphism, thus increasing cryptic camouflage, and reducing predation (Montanucci 1978). Exploitation of hot, xeric habitats has been facilitated by arboreal behavior (Clark 1974). Arboreal behavior allows G. wislizeni to dissipate heat in cooler, above-ground air layers (convectional heat loss).

Specialists

Phrynosoma comprises the only genus specializing in the prey it takes, Formicidae (ants). Species representing Phrynosoma demonstrated elevational relationships within the study area. Phrynosoma solare was found strictly in one lower elevation SHS. Parker (1971) demonstrated a similar habitat relationship (all observations in Sonoran Desert mountain valleys).

Prieto and Whitford (1971) have correlated Phrynosoma douglassi to high elevations, showing P. douglassi to possess a greater preferred temperature range than that of the lower elevation Phrynosoma cornutum, especially at the lower temperature range. They suggested that the lower temperature tolerance of P. douglassi was facilitated by more efficient transport of oxygen, thus allowing exploitation of cooler SHSs. The inability of P. douglassi to exploit low elevations may result from hot ambient temperature regimes that drive deep body temperature above a preferred range, especially considering large amounts of their time are spent in the open foraging. Goldberg (1971) suggested that viviparity of P. douglassi has allowed this species to exploit upper elevation habitats by reducing the effects of cool spring temperatures on developing young.

The replacement of P. douglassi by Phrynosoma platyrhinos at intermediate elevations are not related to competition for prey. Pianka and Parker (1975) demonstrated the ability of P. douglassi to shift its diet to Orthoptera and Coleoptera when overlapping the distribution of P. platyrhinos which relies strictly on ants as prey throughout all areas studies. My data also suggests high dietary dependence of P. platyrhinos on ants. Whitford and Bryant (1979) found highly specialized ant foraging in P. cornutum, and demonstrated an optimum foraging strategy in which only small amounts of ants (Harvestor Ants) were taken at any given nest, thus assuring future supplies of this highly specific food item. Use of ants as a primary food item is facilitated by large stomach volume.

Pianka and Parker (1975) listed other morphological, behavioral, and ecological adaptations that separate Phrynosoma from other lizards and facilitate specialized foraging habits: dorsoventral flattening, spines, short legs, behavior of standing ground when approached by predators; activity over a long period of time, variable body temperatures, specialized ant diet, specialized dentition facilitating ant-eating, production of numerous relatively small eggs/young, and expenditure of considerable amounts of energy on each clutch or litter. Pianka and Parker (1975) also discussed blood squirting from the eye of Phrynosoma solare in efforts to detract predators.

Populations of sit-and-wait predators of open spaces are reduced by loss of low-height vegetation and cover (Jones 1979b,1981a). Heavy grazing in the Hualapai-Aquarius planning units may have decreased numbers of certain sit-and-wait foragers. Although my figures indicate stable populations, they are inconclusive due to small sample size.

Phrynosoma populations may be indicators of range condition because ant nests increase with grazing pressure, and Phrynosoma populations vary directly with ant-nest densities (Whitford and Bryant 1979).

Herbivorus

The species Dipsosaurus dorsalis and Sauromalus obesus present similar management problems: both require plant material in their diets (Norris 1953; Berry 1974). From a management standpoint, it is important to maintain maximum production of vegetative components in the early spring and throughout the summer.

D. dorsalis changes its diet; foraging primarily on creosote bush buds in the spring and composite annuals and perennials in the summer (Norris 1953). It forages both in open spaces and above the ground in creosote bush (Norris 1953). The ability to forage in sparsely vegetated creosote bush SHSs is facilitated by high mean preferred body temperatures (De Witt 1967). Tolerance of temperatures above preferred ranges occur only when lizards are involved in territorial combat or escaping a predator (not during foraging, De Witt 1967). Arboreal behavior observed in D. dorsalis is a mechanism allowing for foraging on creosote bush buds and at the same dissipating heat to cooler air stratum (convective cooling during warm morning hours) (De Witt 1967).

Herbivory of D. dorsalis may account for slow juvenile growth rates and low yearly recruitment (Parker 1972), making this species more susceptible to environmental changes. Species with low recruitment cannot tolerate rapid changes in their surroundings that lower the fitness of existing members of the population.

S. obesus has broader dietary constituents than D. dorsalis, foraging on a variety of shrubs, annuals, and forbs (Johnson 1965; Berry 1974). Loss of dietary constituents, as occurs in heavily grazed areas, could reduce the number of S. obesus by lowering the carrying capacity. S. obesus, however, is restricted to extremely rocky hillsides where few cattle graze. My observations of this species indicate healthy populations (large juvenile and sub-adult composition).

Similar to D. dorsalis, S. obesus has low yearly recruitment (in some areas females reproduce once every 2 years), and emphasizes longevity (Johnson 1965). Populations dependent on high survival rates to offset low recruitment are highly susceptible to catastrophic events, such as rapid changes in the environment.

Unlike studies by Johnson (1965), my studies found D. dorsalis and S. obesus to be sympatric, which probably results from large amounts of creosote bush occurring in saguaro-palo verde SHSs.

Johnson (1965) demonstrated widely-foraging behavior in S. obesus, made possible in hot, rocky desertscrub environments by the use of a panting mechanism and by the possession of a high mean preferred deep body temperature range (Case 1972). Panting allows S. obesus to maintain deep body temperature up to 4.0 C. cooler than the environment, thus extending the period of preferred temperature range needed for activity.

NOCTURNAL

Open Foraging

Coleonyx variegatus was placed into this group of foragers because of large home ranges and open space, opportunistic feeding habits (Parker 1972b). This rather translucent species has exploited desert habitats by adopting nocturnal activity and low preferred temperature ranges (Brattstrom 1965). Brattstrom (1965) also demonstrated this species' use of road surfaces in maintaining preferred temperatures. Because road temperatures are generally greater than soil tempertures, Brattstrom suggests that C. variegatus is more likely to use road surfaces for ventral basking. Roads, therefore, may place selective pressure on this species due to vehicular mortality.

Like C. draconoides, C. variegatus matures in less than 1 year, maintains almost yearlong activity (9 months), and produces up to three clutches per year (Parker 1972b).

Fossorial-Surfacoreal

The genus Xantusia was placed into a separate group because of small home ranges, nocturnal activity, and existence on, in or under downed vegetative litter. Populations of Xantusia vigilis vigilis in Arizona differ from those in California. The Arizona populations occur in foothill and hillside situations dominated by Nolina bigelovi and the California populations occur in valley Joshua tree habitat (Smith 1971). High moisture retention created by downed Nolina bigelovi may allow X. v. vigilis to exploit Sonoran Desertscrub habitats in Arizona. Correlation of X. v.vigilis with cool, mesic environments is consistent with the findings of Kour and Hutchison (1970). They found X. v. vigilis acclimated the least to hot ambient temperature regimes and the greatest to cool ambient temperatures. They also found X. v. vigilis to possess the lowest mean critical minimum deep body temperature of the species. Zweifel and Lowe (1966) examined X. v. vigilis and determined similar ecological relationships. Studies by Cowles and Burleson (1944) determined that high temperatures sterilized male X. v. vigilis. This relationship may further restrict X. v. vigilis to moist, cool environments.

Xantusia vigilis arizonae has received little attention, a result of relatively small, limited populations. I found this species in rocky chaparral SHSs similar to habitats described by Stebbins (1966). Yucca bacata was always present where X. v. arizonae were found. My observations suggest that X. v. arizonae is ecologically similar to X. v. vigilis, dependent on litter (dead Yucca bacata) and nocturnal activity for existence within the study area. Exploitation of high elevation, closed chaparral SHSs suggest X. v. arizonae may have a lower preferred deep body temperature range than X. v. vigilis (although not conclusive, Brattstrom 1965 demonstrated X. v. vigilis to possess a mean preferred body temperature of 30.0 C and X. v. arizonae 25.0 C). Strict habitat structural requirements of these two subspecies account for low habitat use diversities within the study area.

Management of these two species of lizards should include the preservation of litter in their habitat. These species' limited movement and heavy dependence on downed litter could lead to their elimination due to habitat alteration. Harvesting of Yucca and Nolina should be restricted in areas inhabited by these lizards. Careful monitoring of projects requiring roads, clearing, and habitat modification is extremely important.

CREPUSCULAR

Olfaction and Digging

Heloderma suspectum demonstrated high positive correlation with the number of avian ground nests. Bogert and Del Campo (1956) discussed eggs as preferred food items but also included small mammals in the diet. Bogert (1956) also suggested that H. suspectum's ability to smell out food enabled it to forage at night on rodents. H. suspectum may utilize eggs when available in the late spring and summer and small mammals when eggs are not available.

Bogert and Del Campo (1956) suggested that H. suspectum's mostly nocturnal activities are facilitated by mean preferred body temperatures of 27 C. My findings, however, indicate extensive diurnal activity, many lizards being observed moving about during warm, daylight hours. Diurnal activity may be facilitated by patchy, low-height vegetation that allow H. suspectum to avoid direct solar insulation and maintain cooler deep body temperatures.

Because it is venomous, bold, and large H. suspectum is feared by man and is often needlessly killed. Increasing the knowledge of people within the area as to the importance of this animal in the natural ecosystem should reduce killings. This species should be protected from collectors by urging local ranchers and townspeople to report any collecting violations.

Generally, management for lizards should include increasing perennial production and low-height vegetation (excluding Gutierrezia), assuring natural litter deposition in all habitats, minimizing roadbuilding, and restricting harvest of vegetative components (dead or alive) important to the existence, maintenance, and re-establishment of a given species of lizard.

REPTILIA - SQUAMATA - SERPENTES (OPHIDIA)

Ecologically, snakes are probably the least understood, a result of low abundance (compared to lizards) and difficulty observing them. Stebbins (1966), Fowlie (1965), and Wright and Wright (1971) summarize existing information on snake ecology pertaining to reproduction, habitat preference, and distribution and this information is supplemented by studies on specific snake species.

From existing information on life histories of snakes and my own data I grouped snakes into different ecological life forms (Table 7).

Surfacoreal - (Lizard Foragers)

Elevational differences observed for diurnal lizard foragers are related to differences in preferred body temperatures and other physiologicl adaptations. Masticophis flagellum and Salvadora hexalepis, inhabitants of primarily low elevation SHSs, have the highest mean preferred body temperature (MPT) of snakes (Brattstrom 1965; Jacobson and Whitford 1971). Jacobson and Whitford (1971) demonstrated a MPT of 33.0 for S. hexalepis and a thermal tolerance range of 36.8 C greater than all snakes and lizards except for P. douglassi (Prieto and Whitford 1971). This high thermal range in part explains this species high habitat use diversity (highest of the snakes). High MPT has allowed S. hexalepis to exploit hot, low elevation environments as a diurnal lizard eater. Large thermal tolerance, especially at the low range, allows S. hexalepis to emerge from cover sites and into cool air temperatures to bask.

Like S. hexalepis, M. flagellum have large thermal tolerance ranges 45.4 C (Brattstrom 1965). M. flagellum also possess an ability to maintain deep body temperature below ambient temperatures for short periods of time, especially when subjected to hot environments (Jones 1979a). This mechanism allows M. flagellum to extend the diurnal foraging time in which deep body temperature is maintained within a preferred range. Reduction of heating capacities appears to be a disadvantage to a snake that requires rapid heating during earlier morning hours to attain an internal temperature necessary for foraging lizards. Hammerson (1977) revealed that M. flagellum possess circulatory mechanisms allowing the cranial areas to heat quickly. This mechanism allows M. flagellum to emerge from its burrow at relatively low, deep body temperatures (T_b) but with adequate neurological coordination.

M. flagellum in different habitats differ in foraging behaviors. Jones (1979a) demonstrated that creosote bush-dwelling M. flagellum possess only active search predation, whereas mesquite dune-dwelling M. flagellum use active search and sit-and-wait predation. Sit-and-wait foraging in mesquite dune habitat is facilitated by shade trees. Similar differences may occur within the study area between populations in creosote bush SHSs and brushy shade-providing SHSs (e. g. mesquite bosques).

The replacement of M. flagellum and S. hexalepis by Masticophis bilineatus and Masticophis taeniatus may be a result of ambient temperature regimes that are unfavorble for maintenance of preferred ranges of the former two and favorable for the latter two.

Parker (1976) and Hirth et al. (1969) studied populations of M. taeniatus associated with hibernacula. Hirth et al. (1969) found that this species ranged 1.5-3.6 km from the hibernaculum. Parker (1976) estimated dispersed M. taeniatus population densities to be 0.15-0.22/ha. Bennion and Parker (1976) demonstrated reproductive characteristics that account for low population densities. Male M. taeniatus practice specific territorial and combat rituals that favor more experienced individuals and results in subordinate males not reproducing for several years. Female M. taeniatus do not reproduce until their third year and generally produce one clutch per year. Upland habitats have approximately half the food of lower elevation SHS (Table 2) and thus have lower carrying capacities for the diurnal lizard eater, M. taeniatus. The lack of food at higher elevations may account for lower abundance figures of this species at higher elevations than at lower ones.

M. taeniatus may establish hibernacula within the study area. This wintering behavior is adaptive in cool upland areas, since it increases male-female interaction, which is advantageous to snakes with low recruitment and limited yearly activity cycles (due to cool spring and fall temperatures).

The ability of M. taeniatus to home back to specific den sites has been demonstrated by Hirth (1966). Hirth also demonstrated that return to specific hibernacula increased winter survival.

Other than information available in field guides (Wright and Wright 1971; Fowlie 1965; Stebbins 1966) data on M. bilineatus are largely limited to my findings. Vitt and Ohmart (1975) observed one clutch of seven eggs in M. bilineatus and suggested this species showed reproductive strategies of an upland, mesic-environment snake.

Diurnal lizard foragers seem to be well established in the study area and should remain so under present conditions. Management should emphasize protection of hibernacula. Parker (1976) suggests that man has played a major role in reducing the number of these snakes by killing them at hibernaculum entrances. Elimination of snakes at one hibernaculum could wipe out populations covering an area up to 3 square miles involving 500 or more individuals.

NOCTURNAL

Fossorial

The secretive, subterranean existence of this group of snakes and their limited above-the-ground activity, makes obtaining data on them difficult.

Leptotyphlops humilis demonstrated a wider distribution than expected. Stebbins (1966) suggested that this species exploits rocky and moist hillsides and foothills. My findings support those of Stebbins (1966).

Studies by Punzo (1974) showed L. humilis to be more surfacorial than Leptotyphlops dulcis, particularly in areas of sympatry. L. humilis also feeds on some surfacorial arthropods, but is mostly fossorial, as evidenced by high percentages of ants and termites in it's diet. Punzo (1974) showed

L. humilis to be an opportunistic forager, as indicated by other food items taken at termite nests. Studies by Watkins et al. (1967) showed L. humilis to utilize ant pheromones in locating food.

As indicated by Stebbins (1966), little is known about the habits of Tantilla planiceps. A review of the genus Tantilla by Tanner (1966) demonstrated the study area to be a void between populations of T. p. utahensis and T. p. atriceps, with the former occurring to the northwest and the latter to the southeast. Hahn and May (1972) verified T. p. atriceps near the Santa Maria River on Highway 93. Specimens obtained in this study keyed to T. p. atriceps and were verified in the Wikieup area. This information helps bridge the gap between the two subspecies indicated by Tanner (1966).

Information from this study indicates T. p. atriceps distribution to be related to mesic habitat. Jones (unpubl. data) demonstrated similar habitat preference for T. p. atriceps. Unlike Jones, I was unable to verify this species in chaparral communities.

Hypsiglena torquata exploits a variety of habitats, feeding primarily on lizards (Stebbins 1966). Stebbins (1966) suggests that this snake preys on inactive lizards at a variety of cover sites, using an immobilizing venom to secure its prey. Reproductive information on H. torquata is limited to studies by Vitt and Ohmart (1975) and Clark and Lieb (1973) who determined an average of three eggs per clutch and two clutches per year.

Phyllorhynchus decurtatus was verified along the Big Sandy River near Wikieup, a location consistent with habitat descriptions of Stebbins (1966) and Wright and Wright (1971). The record at Wikieup significantly extends the distribution of this species northwest of that reported by Hahn and May (1972). Field observations reveal that the activity of P. decurtatus is limited to moist summer months of July and August. Limited, nocturnal activity has allowed this species to exploit desert environments.

Sonora semiannulata occurs in areas of sandy or loose soil where subsurface moisture prevails (Stebbins 1966). My findings indicate this species is one of the more common nocturnal fossorial snakes within the study area.

Stebbins (1966) discussed the species Micruroides euryxanthus as an inhabitant of a variety of vegetative communities. My observations indicate that this species is strictly related to mesquite washes adjacent to rocky hillsides where sand substrate seems to facilitate burrowing. Vitt and Hulse (1973) determined food preferences for M. euryxanthus, finding L. humilis and other smooth snakes to constitute the majority of the diet. M. euryxanthus habitat strictly overlaps that of L. humilis, probably because L. humilis is a primary food item. Vitt and Hulse (1973) demonstrated high percentages of tail breaks, which they attributed to effective predator escape facilitated by tail-curling and cloacal popping (tail mimics head).

NOCTURNAL

Surfacoreal

Rhinocheilus leconti and *Arizona elegans* are two of the most common snakes in our study area, foraging at night on rodents and inactive lizards (Stebbins 1966; Jones 1979a).

R. leconti demonstrated preferred temperature ranges typical of nocturnal snakes (x=25.0 C, Brattstrom 1965). Low preferred body temperatures and nocturnal activity have allowed *R. leconti* to exploit desert environment.

Similar to *R. leconti*, *A. elegans* has low preferred deep body temperature ranges (MPT 27.0 C, Brattstrom 1965) and nocturnal activity periods.

Jones (1979a) determined foraging strategies of *A. elegans*, finding this snake moved from burrow to burrow feeding on inactive diurnal lizards. Their nocturnal feeding reduces competition with diurnal lizard foragers.

Reproductive information of this group of snakes is limited to research on *R. leconti* by Vitt (1975), where one clutch of three eggs was observed.

NOCTURNAL

Arboreal

Arboreal snakes are described as snakes that spend a majority of their time on large boulders and rocks, and in trees.

Lichanura trivirgata gracia were verified in several isolated areas consisting of high percentages of large boulders and rocks. This species is live-bearing - (viviparous) (Stebbins 1966), a characteristic adaptive to a rock-dwelling snake (lacks suitable nest sites for eggs).

Gorman (1965) reviewed the distribution of *L. t. gracia*, finding no populations north of the Ajo Mountains. Hahn and May (1972), however, verified *L. t. gracia* at Nowhere, Arizona on Highway 93, and later this species was verified to the northwest in the Cerbat and Hualapai Mountains (Jones *et al*. 1981).

Populations of *L. t. gracia* are isolated and estimated as small. Further studies are needed to determine specific habitat management for this species. The biggest threat to existing populations is collection by man. Legislation prohibiting its collection and sale should be drafted and implemented. *L. t. gracia* is listed as sensitive by the Bureau of Land Management in Arizona.

Trimorphodon biscutatus lambda occurs in low-to-mid-elevation (2200-4000 ft), rocky habitat, but is suggested to occur at elevations up to the ponderosa pine SHS (Stebbins 1966). This study indicates a preference for rocky hillsides of the palo-verde SHS. Jones (unpubl. data) also demonstrated T. b. lambda to climb several feet above the ground in mesquite trees.

Stebbins (1966) suggests that T. b. lambda preys on small mammals and lizards. Jones (1981b) observed different capture strategies, depending on the type of prey pursued. T. b. lambda captured lizards by grasping at their heads and holding them for several minutes until immobilized. T. b. lambda grasped and constricted rodents for 3 to 5 minutes with four tight coils. The difference in foraging strategies may result from the ineffectiveness of Trimorphodon venom to immobilize rodents but its effectiveness in subduing lizards.

CREPUSCULAR

Aquatic

Thamnophis cyrtopsis and Thamnophis marcianus demonstrate distributions closely associated with water (Stebbins 1966). Fleharty (1967) concluded that T. cyrtopsis prefer rocky, wet areas, which permit escape into pools to avoid predators. Wet areas also support primary food items of this species (Fouquette 1954). Of the prey consumed, 35% were adult toads and frogs and 61% were tadpoles. My observations support findings of Fleharty (1967) and Fouquette (1954) since T. cyrtopsis was found strictly associated with wet, rocky areas, and on two occasions, observed feeding on tadpoles. This species also escaped into water when approached.

Van Devender and Howard (1973) hypothesized that the mid-dorsal stripe of many Thamnophis, combined with lateral dark striping, give these animals a concave appearance, confusing predators as to their size and enhancing escape. Van Devender and Howard (1973) also hypothesized that lateral striping creates the illusion that snakes are moving faster than they actually are, further confusing predators.

Brattstrom (1965) demonstrated that Thamnophis possess relatively low preferred body temperature ranges. Cool waters (where this species spends a majority of its time) help T. cyrtopsis maintain low preferred temperature ranges (Fleharty 1967). Steward (1965) also demonstrated use of water in maintaining cool, preferred body temperatures.

This genus's strict distributional ties to wetlands makes its risk of elimination from our area higher than that of most species. I recommend protecting riparian areas from actions that reduce frog and toad reproduction, primarily dewatering from ground pumping. Mining activities that require dumping of effluent into floodplains should be eliminated if this genus is to continue existence in the study area.

CREPUSCULAR

Fossorial

Unlike most snakes, Diadophis punctatus has received considerable attention. Stebbins (1966) illustrates an isolated population of this species in northern sections of the Hualapai Mountains (one record in this study).

Diadophis punctatus regalis (found in the study area) is the largest of all subspecies (Wright and Wright 1957). Gehlback (1974) concluded that the large size of this subspecies allows for the exploitation of xeric, Madro-tertiary Geoflora, reducing desiccation. In another study, D. punctatus was the only small colubrid to select habitat independent of cutaneous water loss (Elick and Sealander 1972). This snake's independence from water loss through the skin is an adaptation that allows for exploitation of desert environments.

Relatively large sizes of juvenile D. punctatus have resulted in decreased mortality; as a result the species produces fewer eggs and has a low population turnover (Vitt 1975). The relatively long lifespan of D. punctatus, documented by Parker and Brown (1974), combined with small clutch size and low population turnover, make this species less adaptive to rapid environmental changes than species with high turnover and large clutches.

Buikema and Armitage (1969) demonstrated acclimation of metabolic functions of D. punctatus in response to various temperature regimes. Metabolic acclimation over a wide variety of temperatures, combined with a wide voluntary internal temperature range (Voluntary Maximum - Voluntary Minimum, Brattstrom 1965) are adaptive to a small crepuscular snake that exploits xeric environments (wide variety of ambient temperatures).

The Hualapai Mountains have an isolated population of Lampropeltis pyromelana, existing in upper elevation SHSs. Stebbins (1966) recognizes this population and suggests dependence on perennial water. My findings support Stebbins (1966) and verify his supposition that L. pyromelana forages on small mammals. I observed one individual regurgitating three small mammals near a streambed. The same individual ate two laboratory mice while held in captivity. Consumption of small mammals may allow L. pyromelana to maintain activity during cool spring and fall months when lizards are scarce.

Further studies are needed to determine population densities of L. pyromelana in the Hualapai Mountains. I contend that this species possesses small population numbers and highly recommend the protection of riparian areas and perennial drainages in upper elevation SHSs. Downed branches and trunks of trees should be left in place to assure cover sites for this species.

CREPUSCULAR

Surfacoreal

This group represents a broad variety of snakes that feed primarily on small mammals.

Lampropeltis getulus differs from other crepuscular-surfacoreal snakes in that lizards and snakes constitute a majority of its diet (Stebbins 1966; Wright and Wright 1957).

I observed the greatest abundance of L. getulus along drainages and near water, possibly a result of greater food and cover availability in drainages than in adjacent areas.

Brattstrom (1965) reported a mean preferred body temperature of 28.1 C and a relatively low voluntary minimum, 15.0 C, for L. getulus. Low preferred temperature ranges and voluntary minimums allow L. getulus to maintain activity during cool springtime diurnal hours and cool nocturnal summer hours.

The genus Lampropeltis has evolved partial immunity to rattlesnake venom (Carpenter and Gillingham 1975). This mechanism allows L. getulus to feed on the study area's most common snakes. To reduce predation by Lampropeltis, crotaline snakes have evolved an alternate defense behavior (Carpenter and Gillingham 1975). When approached by Lampropeltis, these snakes inhale air (makes the snake appear larger) and then strike the ground with the midsection of their body.

Pituophis melanoleucus was one of the most common snakes in the study area. Greenwald (1969) suggested that P. melanoleucus spends a majority of its time foraging. He found the species to have a high metabolic scope, facilitating long activity periods and high frequencies of prey constriction.

A majority of the diet of P. melanoleucus consists of small mammals, birds, and bird eggs (Stebbins 1966). Austin et al. (1973) documented predation of cactus wrens and their eggs by P. melanoleucus. Although predation of this bird is often successful, dead P. melanoleucus impaled by cholla spines were observed at or around nest sites.

Bogert and Roth (1966) demonstrated ritualistic combat among P. melanoleucus. This mechanism is adaptive since it facilitates the expression of more experienced males in the gene pool.

Members of the genus Crotalus represent the West's only dangerous snakes to man; a result of advanced poison injection and striking mechanisms (Klauber 1972). Crotalines have also evolved heat sensory pits that facilitate nocturnal foraging of homoiothermic animals (Klauber 1972).

In reviewing preferred body temperatures, Brattstrom (1965) documented little difference in species of the genus *Crotalus*. The exploitation of higher elevation SHSs by *Crotalus viridis cerberus* and *Crotalus molossus* seem not to be related to preferred temperature range. These two species may exploit upland habitat through limited activity periods and use of hibernacula. Use of hibernacula in Utah populations of *C. viridis* have been shown to increase winter survival (Hirth and King 1968; Hirth, *et al*. 1969). Denning also increases the probability of male-female interaction in early spring (Hirth, *et al*. 1969).

I observed four dens of *Crotalus atrox* (low elevation). Similar to denning by *C. viridis*, such denning increases male-female contact of *C. atrox*, thus assuring reproduction.

The similarities in distribution and morphology of *C. atrox* and *Crotalus scutulatus* have led some authors to believe that these species interbreed. Jacob (1977) evaluated this possibility, and although he did not rule out interbreeding, suggested it as highly unlikely.

Crotalus cerastes exploited only creosote bush SHSs within the study area which is partially facilitated by burrowing and midsummer nocturnal activity periods (Klauber 1972). The inability to exploit other habitats may result from cool springtime nocturnal temperature regimes and the lack of loosely compacted alluvial soils. Cowles and Bogert (1936) found that *C. cerastes* forage at night during the spring, since their small size allows them to consume only small animals. Lizard foraging, they concluded, was ineffective due to scarcity of lizards in the spring. Unlike *C. cerastes*, *Crotalus mitchelli* forage both large and small prey items, allowing them to forage during the day (e.g. ground squirrels).

Habitat managment plans for crotaline snakes should emphasize protection of denning areas. As mentioned for *M. taeniatus*, entire populations of rattlesnakes can be wiped out at den sites. Hirth and King (1968) discussed similar problems in Utah. They demonstrated rattlesnake populations to be well below carrying capacity, concluding that man was mainly responsible. The western portion of the Hualapai Mtns. demonstrates a similar problem. Alamo Road runs along several den sites at the western edge of the Hualapai Mountains. I observed several dead rattlesnakes along this road with heads and tails chopped off.

Den sites should be fenced and ranchers and other residents should be informed of the importance of these snakes in the natural ecosystem.

In summary, management for snakes should include maintenance of ground litter, restriction of roadbuilding, protection of den sites, protection and maintenance of riparian areas, reduction of commercial collectings, reduction of killings by man, and enhancement of range conditions.

HABITAT MANAGEMENT

Three important factors must be considered in recommending habitat management schemes for reptiles and amphibians: condition of the animal species including population trend and limiting factors (e.g., foraging specialization), habitat condition including habitat structural diversity and cover, and land and resource actions that have accounted for present species and habitat conditions and will continue to be a factor in the future. This includes land actions that presently have little effect on reptiles and amphibians and their habitats, but could in the future.

Significant Species

I have developed and determined species relations with standard habitat sites, relationships between reptile and amphibian species and habitat structure, and other ecological relationships important in maintaining species existence in an area. I have also made general recommendations for maintaining and improving each group of reptile and amphibian. There is a group of reptiles and amphibians, however, demonstrating ecological relationships and population dynamics that I feel represent declining or sensitive situations (Table 8). Generally the factors that will maintain and/or enhance the condition of these reptiles and amphibians can be applied planning area-wide over a wide variety of standard habitat sites. Table 8 summarizes each of these significant reptiles and amphibians's limiting factors and makes specific recommendations to maintain and/or improve each species (depending on whether the species is presently in danger of extirpation). A majority of the recommendations are habitat improvement or maintenance, with only a small number representing legislation and other needs.

Significant species designation for the planning area was consistent with BLM objectives established under Manual 6840 (BLM 1979) and the Arizona State Office directives. I recommend, however, that the species listed in Table 8, other than Federal, State, and BLM sensitive, be recognized as significant only for the Hualapai-Aquarius planning area. These species can be requalified based on specific inventory information obtained in upcoming planning areas.

Management of Faunal Richness

Determination of maximum faunal richness for a given standard habitat site has been a difficult problem to access, primarily because of differences in ecology of the major taxinomic groups within the herpetofaunal community. My studies and studies of Jones (1979b and 1981a) on lizard populations in relation to livestock grazing present a better picture as to what conditions of range support the greatest abundance and diversity of reptiles and amphibians for a given standard habitat site. I demonstrated fair condition desert grassland to support greater abundance and diversity of lizards than poor condition desert grassland. I hypothesized that fair condition sites provided more favorable conditions to "widely foraging" species due to increased cover and low-height

TABLE 8 - Significant species of the Hualapai-Aquarius planning area. Limiting factors are A = low abundance, B = low reproductive capacities, C = declining population trends, D = denning activities, E = over-collection, F = road kills, G = habitat specific, H = habitat structural specific, I = limited habitat, J = deteriorating habitat quality, K = specialized diet, L = reputation. Status abbreviations are F = federally listed, S = Arizona state listed, and SB = Bureau of Land Management sensitive species.

Species	Status	Limiting factors	Recommendations
Bufo alvarius	-	A, G, I	---------------
Ambystoma tigrinum	-	A, G, I	Additional studies on distribution
Gopherus agassizi	S	A, B, C, E, F, J, K	Increase range condition to good (SCS 1976). Prohibit collecting. More studies.
Kinosternon sonoriense	-	G, I, J	Maintain or increase surface waters of the Upper Bill Williams River drainage. Prevent de-watering of river by Cyprus-Bagdad and other operations.
Kinosternon flavescens	-	G, I, J	As above.
Eumeces gilberti arizonensis	S	A, B, C, G, H, J	Increase all range sites to good condition with particular emphasize on perennial grasses. Prohibit collection. Expand Cottonwood riparian communities.
Eumeces obsoletus	-	A, B, C, G, H, J	As above.
Cnemidophorus exanguis	-	A, C, H, J	Increase all range sites inhabited by this species to good condition with specific efforts to increase the composition of perennial grasses.
Cnemidophorus velox	-	A, C, H, J	As above.
Phrynosoma sp.	-	K	Maintain or increase condition of range within inhabitance of these species to fair-good.
Dipsosaurus dorsalis	SB	B, K	Delist from BLM sensitive species list.
Sauromalus obesus	-	B, K	Increase forb and wildflower production of range sites in which this species occurs.
Xantusia arizonae	SB	A, B, G, H, I	Prohibit harvest of live and dead Yucca bacata at Interior Chaparral and Pinyon-juniper SHS's. Additional studies.
Xantusia vigilis	SB	B, G, H, I	Prohibit harvest of live and dead Nolina bigelovi. Restrict harvest of Yucca schidegra. Additional studies.
Heloderma suspectum	S	A, B, E, F, H, J, L	Increase low-height vegetation in Palo Verde - Saguaro and Open Chaparral SHS's by establishing good condition range sites.
Lichanura trivirgata gracia	SB	A, B, E, F, G, H	Improve water quality of Cyprus - Bagdad and Boriana Mine operations. Prohibit any kind of collecting. Additional studies.
Diadophis punctatus	-	B, G, I	Additional studies.
Lampropeltis pyromelana	S	A, E, G, H, I, L	Prohibit removal of downed litter (limbs, logs, and leaf litter) in the Pine-oak and Mixed Broadleaf riparian SHS's. Prohibit collection. Increase surface water of Pine-oak SHS's. Prevent spring development that illiminates surface water. Educate local residents that this snake is non-poisonous.
Masticophis taeniatus	-	B, D, G	Additional studies to determine and protect den sites.
Thamnophis sp.	-	G, I, J, K	Improve water quality of the Upper Bill Williams drainage below the Cyprus-Bagdad mining operation. Prevent any further dewatering of the Upper Bill Williams River. Prevent any spring development where these snakes occur that will eliminate surface water.
Crotalus atrox	-	D, F, L	Prevent wanton killings by increasing knowledge of local residents and if necessary adopt legislation prohibiting unnecessary killings. Fence off known den sites and withdraw these areas from other land use considerations.
Crotalus cerastes	-	G, H, I, L	As above but delete den site recommendations.
Crotalus mitchelli	-	D, L	As in C. atrox
Crotalus molossus	-	A, D, L	As above
Crotalus scutulatus	-	D, F, L	As above
Crotalus viridis cerberus	-	D, G, L	As above
Micruroides euryxanthus	-	A, G, I, K, L	Additional studies.

vegetative structure. High low-height composition throughout all SHSs should result in stable and/or increasing populations of "widely foraging" species. It should also favor surfacoreal, fossorial, and arboreal snakes that forage on this group of lizards.

The amount of low-height vegetative structure, particularly perennial grasses, throughout the planning area is low (BLM 1979). I hypothesize, therefore that low abundance of "widely foraging" species, with the exception of Cnemidophorus tigris, results from lack of low-height perennial structure within each SHS. Higher preferred body temperature ranges and large body size may account for C. tigris' independence of the amount of low-height perennial cover.

Lizards utilizing "sit-and-wait" foraging strategies were generally the most abundant lizards in the planning area throughout a variety of SHSs. I feel this results from large amounts of rocky substrate, downed tree limbs and vegetative litter, and large amounts of woody plants in many of the SHSs. Because of the relatively stable nature of these types of habitat structures within SHSs, I feel little management is needed, with the exception of maintaining reproductive rates of woody plants (e.g. Canotia, Pinus, and Juniperus).

Rodent foragers, primarily snakes and Heloderma suspectum, present different managment problems than "sit-and-wait" and "widely foraging" lizards. Studies by Black (1968) and Peck (1979) indicate small mammal diversity and abundance to be greatest on sites with moderate composition of both perennial and annual plant species. Black (1968) hypothesized that annual seeds provided higher energy food sources during late winter and spring months and perennial seeds an energy source during late summer, fall, and winter months when annuals were not available. Therefore, I contend that upper fair to good condition rangeland would support the greatest rodent prey base to snakes and H. suspectum (range conditions as in the National Range Handbook, SCS 1976 and Jones 1979b).

Upper fair to good condition rangeland would also provide optimum habitat structure to "sit-and-wait" lizards who forage in open spaces between shrubs. Pianka and Parker (1972) determined that a good mixture of open space and low-height cover provided excellent foraging conditions for this group of lizards. This type of condition is typical of upper fair to good conditon rangeland under SCS determinations (SCS 1976).

The ant foraging genus Phrynosoma is also most abundant on rangeland in upper fair to good condition (Whitford pers. comm.), primarily resulting from moderate to high amounts of annual grass that provide harvester ants with high energy food sources (Whitford and Bryant 1979).

Although I have discussed the relationship between lizards and habitat structure, and rodent foraging snakes and prey base, I have not discussed the relationship between habitat structure and invertebrate foraging reptiles. Many of the fossorial snakes and nearly all the lizards with the exceptions of Dipsosaurus dorsalis, Heloderma suspectum, and Sauromalus obesus forage on invertebrates. Unfortunately, little is known of the foraging habits of these reptiles and how invertebrate diversity and abundance affect populations numbers. It is reasonable to surmise , however, that high invertebrate diversity and abundance would provide a highly favorable food base for these reptiles. The greater the variety and abundance of invertebrates, the greater the number of food niches available to reptiles that exploit this type of prey. I would, therefore, expect the diversity and abundance of invertebrate foragers to be greater under such situations. Whitford (pers. comm.) hypothesized that range supporting high diversities of plant structures and plant species had the greatest diversity of invertebrate species.

From a diversity standpoint, upper fair to good condition rangeland would provide habitat structure (vegetative) favorable of supporting the greatest reptilian diversity and abundance. The maintenance and improvement of range to upper fair to good condition should be applied planning area-wide and over all standard habitat sites. The means by which fair to good condition is maintained and/or improved varies depending on the standard habitat site. Table 9 summarizes methods of maintaining and attaining the prescribed range or habitat condition, and in some cases refers to specific areas within the Hualapai-Aquarius Planning Area.

Reptiles and amphibians dependent on water present different management problems than their terrestrial counterparts. Water, although important to species that consume it, is extremely important to species that require water to perform limiting ecological functions, primarily reproduction and foraging. The most important aquatic habitat management considerations are water quality, structure (e.g. percent riffles, percent runs, and percent pools of lotic habitat, and pool depth and bottom compositon of lentic habitat), water persistence, and water distribution.

Water quality requirements of tadpoles, adult toads and frogs, and members of the genus Kinosternon are not well known. It is likely that tadpoles and Kinosternon would be most affected, the former requiring oxygen and temperature gradients for oxygen levels in body fluids, and the latter requiring food items that can only be found in lentic and lotic habitats. Because of strict water related requirements, changes in quality of water could threaten the mere existence of these animals in the planning area. Although I can not recommend specific levels of nitrogen, dissolved solids, carbon compounds, and heavy metals, I do recommend utilizing physical profiles and models established for native fishes and EPA standards as a minimum acceptable level for aquatic ecosystems.

An even dispersal of riffles, runs, and pools provide the most optimum conditions for tadpole, adult frogs and toads (Rana pipiens, Hyla arenicolor, Bufo punctatus, and Bufo microscaphus), Kinosternon, and Thamnophis perpetuation (a result of high diversity of trophic levels which increase the number of niches.) I recommend obtaining a diversity of these conditions with the addition of varying amounts of backwater areas as exemplified by the stretch of aquatic habitat one mile above and below the confluence of Burro and Boulder Creeks on the former.

TABLE 9 - Standard habitat site conditions and management recommendations for the Hualapai/Aquarius planning area.

Standard Habitat Site	Area/s	Maintenance and/or Improvement
Ponderosa Pine	Entire SHS in Hualapai Mountains.	Increase perennial grass compositon to 20% by establishing 2 acre seeded exclosures throughout. Prevent further spring development. Develop rest-rotational grazing system.
Ponderosa - Aspen	Entire SHS in Hualapai Mountains.	Increase perennial grass composition to 20% by establishing 2 acre seeded exclosures throughout. Prevent further spring development. Develop rest-rotational grazing system.
Pinyon - Juniper	Entire SHS in Hualapai Mountains and near junction Highway 93 and I-40.	Increase perennial grass composition to 20% by establishing 2 acre seeded exclosures throughout SHS. Assure reproduction of Yucca bacata through studies and harvest protection. Develop rest-rotational grazing system.
Juniper Mix	Area near Nowhere, AZ. and Banegas well west of Wikieup, AZ.	Prohibit harvest of Yucca schidegra. Fence off rattlesnake dens illustrated in Appendix Develop rest-rotational grazing system.
Interior (Closed Chaparral)	Hualapai Mountains and entire area within boundaries of closed chaparral illustrated in Appendix	Increase perennial grass composition to 20% by thinning selective areas of 100 acres. Establish seed base by constructing 2 acre exclosures. Seed up to 10 species of native grasses. Prohibit harvest of Yucca bacata within this SHS. Develop rest-rotational grazing system.
Open Chaparral	(Same as above)	(Same as above)
Desert Grassland	Goodwin, Bozarth and Nelson Mesas.	Increase perennial grass composition to 40% by elimination of Gutierrezia and seeding. Increase shrub composition through planting and seeding. Develop small rain water catchments for amphibian propagation. Develop intensive (cattle reduction with limited use) rest-rotational grazing system.
Joshua Tree	Valleys of the Hualapai Mountains.	(Appendix). Increase shrub composition to 45%. Increase perennial grass composition to 20%. Develop rest-rotational grazing system with the exception of areas listed in Appendix 4 for Gopherus agassizi. These areas should not be grazed.
Creosote Bush	Yucca, AZ valleys	Increase perennial grass composition to 20% by establishing 2 acre exclosures seeded with 5 native grass species. Develop rest-rotational grazing system. Develop small rain water catchments for amphibian propagation.
Palo verde-Saguaro	Entire SHS.	Increase perennial grass composition to 25% by establishing 2 acre seeded exclosures.
	Six miles south of Bogle Ranch - Sycamore Camp.	Prohibit harvest of live and dead Nolina bigelovi. Develop rest-rotational grazing system.
Canotia Mix	Entire SHS.	Increase perennial grass composition to 30% by establishing 2 acre seeded exclosures. Develop rest-rotational grazing system.
Mixed Broadleaf Riparian	Entire SHS including Francis and Sycamore Creeks.	Increase perennial grass composition by establishing 2 acre seeded exclosures in the sand bottom drainages. Eliminate livestock grazing for a period of 3 years and thereafter utilize a very restricted rest-rotational grazing system. Increase cottonwood, willow, ash, walnut, and sycamore reproduction by seeding. Increase perennial cover on other SHS to reduce flooding effects. Prohibit road building and ORV activities in the drainages. Assure water quality compliance with EPA safe water standards. Prohibit any dewatering activities.
Cottonwood-willow Riparian	Entire SHS including all of Burro, Boulder and Trout Creeks and the Big Sandy and Santa Maria Rivers.	As above with the exception of propagating ash, walnut, and sycamore, and the addition of thinning tamarisk and mesquite.
Mesquite	Entire SHS.	As above with emphasis on expanding cottonwood-willow SHSs into areas of mesquite.

Water distribution is good throughout the planning area (Jones 1977), with large evenly dispersed numbers of springs, earthen dirt tanks, wells, and intermittent and permanent floodplains. The qualtiy of these waters, particularly related to chemistry, is important due to isolated populations of obligate aquatic reptiles and amphibians at these sites (See Appendix 3). There are also many species that tend to congregate at such waters, particularly spring heads (e.g. Lampropeltis pyromelana). I recommend water quality tests at each of these sites to determine any problems that may exist.

Land-Use Conflicts and Mitigation

There are several land-use actions that detrimentally affect reptiles and amphibians (Table 10). Presently, the most severe effects within the Hualapai-Aquarius Planning Area are due to livestock grazing and mining operations (Table 10).

Livestock grazing pressures that result in habitat structural degradation have reduced herpetofauna abundance and diversity throughout the planning area. Jones (1979b and 1981a) demonstrated reduced lizard abundance and diversity when livestock grazing reduced plant structural diversity. My studies and information obtained by the range survey crew (BLM 1979) indicate that large portions of the planning area's range is in poor to fair condition. The elimination of livetock from the rangeland is not necessarily the answer nor is it feasible in a multiple-use land management system. Reduction of numbers and rest-rotational grazing systems are feasible ways of improving range condition throughout the planning area.

Riparian areas are of particular concern in regards to livestock grazing as these habitats can be totally eliminated by overutilization. Livestock feed upon cottonwood seedlings and other deciduous trees, resulting in sterile, non-reproductive riparain communities. In these areas, seedlings must be protected by some type of exclosure, whether fencing of the entire riparian area or sections possessing trees. Table 10 summarizes the planning area's livestock related problems and recommends mitigation.

Mining activities affect native herpetofauna by disturbing and destroying habitat in and around the mining area, degradating water quality in adjacent floodplains, and reducing surface flow of perennial drainages.

Widespread habitat disturbance and habitat destruction occur during exploration and establishment of roads to claims and mines. Vegetation and soil are torn up leaving cleared paths for vehicles and other mining equipment. This type of habitat degradation reduces reptile and amphibian diversity and abundance by reducing cover sites and habitat structure.

Detrimental impacts of mining on water quality and quantity are limited to operations that utilize ground, spring, and stream water. Water quality is important at all sites because both aquatic and terrestrial reptiles and amphibians utilize, to varying degrees, water. All operations throughout the planning area should be tested in regards to water quality

TABLE 10 - Land-use conflicts and their mitigation. Specific areas are listed and illustrated in Appendix 9.

Conflict	Area/s	Mitigation
Livestock grazing	Planning area-wide	Adopt rest-rotational grazing systems planning area-wide. Fence off areas with large tortoise populations and riparian SHSs. In these areas, eliminate grazing. See Table 9 for more detailed recommendations pertaining to range improvement.
Mining	Boriana Mine	Conduct studies to determine water quality of McKenzie Wash. Prohibit any activities in violation of EPA water quality standards.
	Cyprus-Bagdad	As above with the addition of prohibiting any further dewatering of the Upper Bill Williams drainage by the mine.
	Planning area-wide	Monitor all operations involved with water utilization of the natural aquifer and any involved with road construction. Require all claim holders and active opertions to file exploration and mining plans once a year.
Habitat Improvement	Chaparral SHSs	Restrict elimination of scrub-oak from large areas. Thinning should be conducted on areas of no more than 100 acres.
	Planning area-wide	Restrict spring development where surface water may be eliminated.
Recreation (other than ORV)	Planning area-wide	Prohibit campground development in the areas of Rattlesnake dens (See Appendix). Prohibit collection of dead trees and tree limbs from all SHSs. and particularly dead Nolina bigelovi, Yucca schidegra, Yucca bacata, and Yucca brevifolia.
ORV	Planning area-wide	Prohibit off-road usage in drainages riparian areas and roadless areas.
Commercial Plant Harvest	Planning area-wide	Prohibit collection and harvest of plants listed under recreational use. Also prevent removal of deciduous trees from riparian SHSs.
Commercial Reptile and Amphibian Collection		Prohibit any collection of significant species of Table 8. Uphold AZ Game and Fish collecting laws.

to identify any existing problems. Operations that involve perennial streams should be strictly monitored for water quality because of obligate, aquatic reptiles and amphibians that occur there. These operations should also be monitored as to how much water is being removed from the riparian aquifer. In all cases, water use by mines should be restricted to a level that will allow for continued existence both in quantity and quality of present aquatic species diversity.

Harvesting of vegetation for commercial use also may have some long-term detrimental effects on reptiles and amphibians, particularly those species whose existence in the area is dependent on a single plant. Harvesting *Yucca schidegra* and *Nolina bigelovi* could severely impact *Xantusia vigilis vigilis*. My inventory data demonstrated this species to be strictly associated with these plants, particularly *Nolina bigelovi*. I found individuals of *X. v. vigilis* spent great amounts of time in and under individual plants. This is consistent with Zweifel and Lowe's (1966) studies on this lizard. Dead trunks deposited on the ground are as important for inhabitance as the live plant. Without *N. bigelovi* or *Y. schidegra*, it is unlikely this species of lizard would occur within the planning area. Presently, harvest of *Y. schidegra* is ongoing in the planning area. This activity should be restricted until data is obtained on reproductive capacities of this plant species. There are no harvest operations of *N. bigelovi*. I recommend no harvest be allowed until reproductive information is obtained.

Alteration of habitat through use of chaining and burning to improve range quality may detrimentally affect reptiles and amphibians. If burning is employed, it should be restricted to small areas and winter months when most reptiles and amphibians are inactive.

The U. S. Forest Service has, for the past 10 years, recommended and implemented prescribed burning and clearing of chaparral to increase perennial grass composition. My studies demonstrated chaparral SHSs to possess extremely high reptile and amphibian diversity when compared to other SHSs. It also possessed several species that were almost totally restricted to this SHS. I therefore do not recommend elimination of chaparral to expand other habitats. Thinning of *Quercus turbinela* to allow for seeding and establishment of perennial grasses is acceptable but should never involve elimination of this species of oak from a large area.

There are other activities such as off-road vehicle races that result in habitat destruction and species' disturbance. These activities should be restricted to habitats which are large and not discontinuous, that have few significant species (Table 8) and possess stable populations of resident herpetofauna. Although off-road vehicle races are a prime concern to many diverse interest groups, there is presently very little of these activities associated with the planning area.

Table 10 summarizes land-use conflicts for the planning area and makes recommendations for mitigation of such conflicts.

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APPENDIX 1 - Snout-vent measurements (mm) for adult/juvenile cutoffs of 23 species of lizards - (less than) (greater than) -

	Juvenile	Adult
Coleonyx variegatus	- 40 mm	41 mm -
Heloderma suspectum	-175 mm	176 mm -
Callisaurus draconoides	- 50 mm	51 mm -
Cophosaurus texana	- 50 mm	51 mm -
Crotaphytus collaris	- 55 mm	56 mm -
Dipsosaurus dorsalis	- 65 mm	66 mm -
Gambelia wislizenii	- 55 mm	56 mm -
Phrynosoma douglassi	- 40 mm	41 mm -
Phrynosoma platyrhinos	- 35 mm	36 mm -
Phrynosoma solare	- 40 mm	41 mm -
Sauromalus obesus	-105 mm	106 mm -
Sceloporus magister	- 60 mm	61 mm -
Sceloporus undulatus	- 45 mm	46 mm -
Urosaurus orantus	- 35 mm	36 mm -
Urosaurus graciosus	- 35 mm	36 mm -
Uta stansburniana	- 35 mm	36 mm -
Eumeces g. arizonensis	- 60 mm	61 mm -
Eumeces obsoletus	- 55 mm	56 mm -
Cnemidophorus exanguis	- 50 mm	51 mm -
Cnemidophorus tigris	- 55 mm	56 mm -
Cnemidophorus velox	- 50 mm	51 mm -
Xantusia arizonae	- 30 mm	31 mm -
Xantusia v. vigilis	- 20 mm	21 mm -

APPENDIX 2 - Scientific - common name cross-reference.

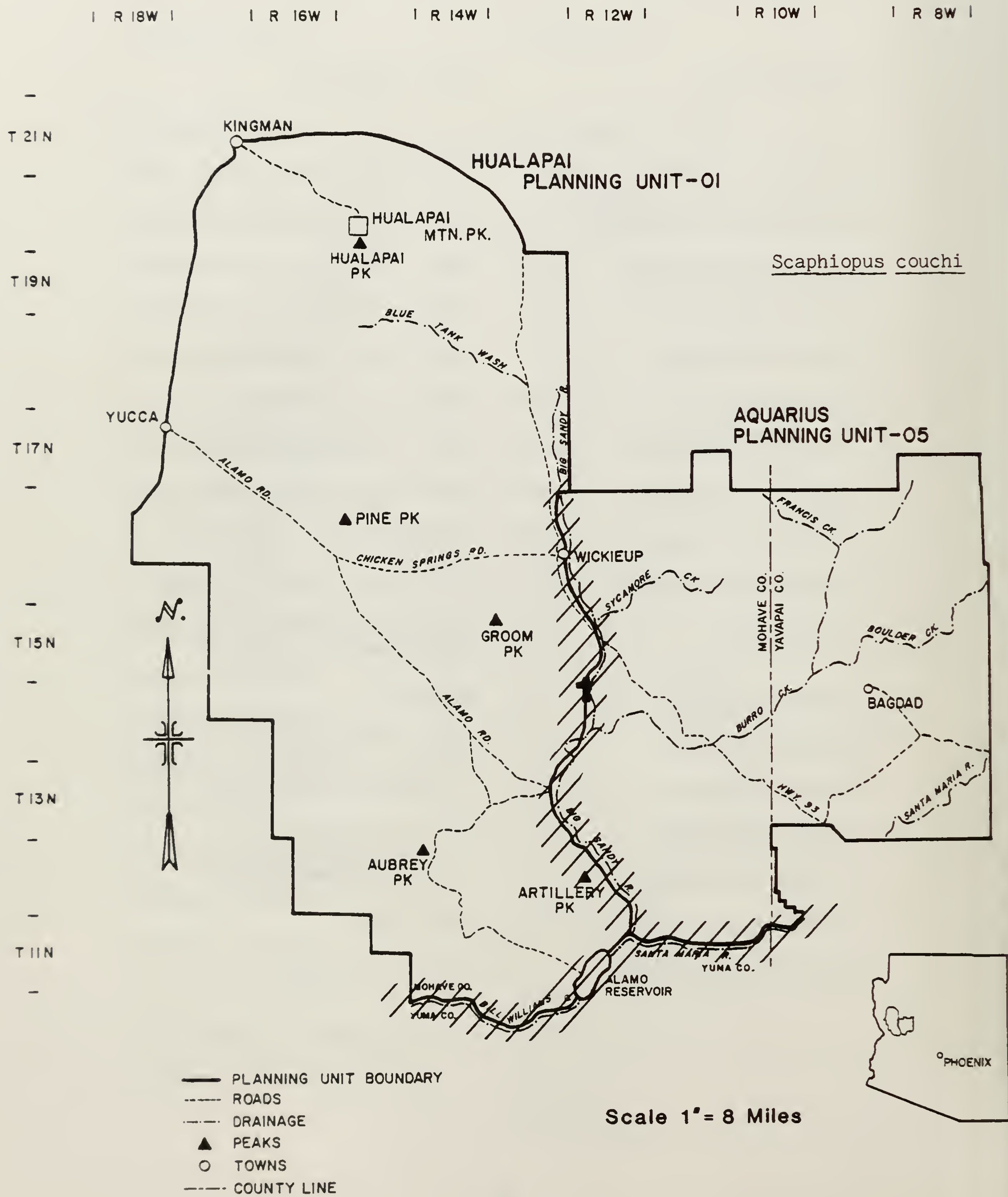
Scientific Name		Common Name
Scaphiopus couchi	-	Couch's Spadefoot Toad
Bufo alvarius	-	Colorado River Toad
Bufo microscaphus	-	Southwest Toad
Bufo punctatus	-	Red-spotted Toad
Bufo woodhousei	-	Woodhouse's Toad
Rana pipiens	-	Leopard Frog
Hyla arenicolor	-	Canyon Tree Frog
Ambystoma tigrinum	-	Tiger Salamander
Kinosternon flavescens	-	Yellow Mud Turtle
Kinosternon sonoriense	-	Sonora Mud Turtle
Gopherus agassizi	-	Desert Tortoise
Trionyx spiniferus	-	Soft-shelled Turtle
Coleonyx variegatus	-	Banded Gecko
Heldorma suspectum	-	Gila Monster
Callisaurus draconoides	-	Zebra-tailed Lizard
Cophosaurus texana	-	Greater Earless Lizard
Crotapohytus collaris	-	Collared Lizard
Dipsosaurus dorsalis	-	Desert Iguana
Gambelia wislizeni	-	Leopard Lizard
Phrynosoma douglassi	-	Short-horned Lizard
Phrynosama platyrhinos	-	Desert Horned Lizard

Scientific Name		Common Name
Phrynosoma solare	-	Regal Horned Lizard
Sauromalus obesus	-	Chuckwalla
Sceloporus magister	-	Desert Spiny Lizard
Sceloporus undulatus	-	Southern Plateau Lizard
Urosaurus graciosus	-	Long-tail Brush Lizard
Urosaurus ornatus	-	Tree Lizard
Uta stansburiana	-	Size-blotched Lizard
Eumeces g. arizonensis	-	Gilbert's (Arizona) Skink
Eumeces obsoletus	-	Great Plains Skink
Cnemidophorus	-	Chihuahuan Whiptail
Cnemidophorus tigris	-	California Whiptail
Cnemidophorus velox	-	Plateau Whiptail
Xantusia arizonae	-	Arizona Night Lizard
Xantusia v. vigilis	-	Desert Night Lizard
Lichanura t. gracia	-	Rosy Boa
Arizona elegans	-	Glossy Snake
Chionactus occipitalus	-	Western Shovel-nose Snake
Diadophis punctatus	-	Ring-neck Snake
Hypsiglena torquata	-	Night Snake
Lampropeltis getulus	-	California King Snake
Lampropeltis pyromelana	-	Mountain King Snake
Masticophis flagellum	-	Coachwhip
	-	Striped Racer

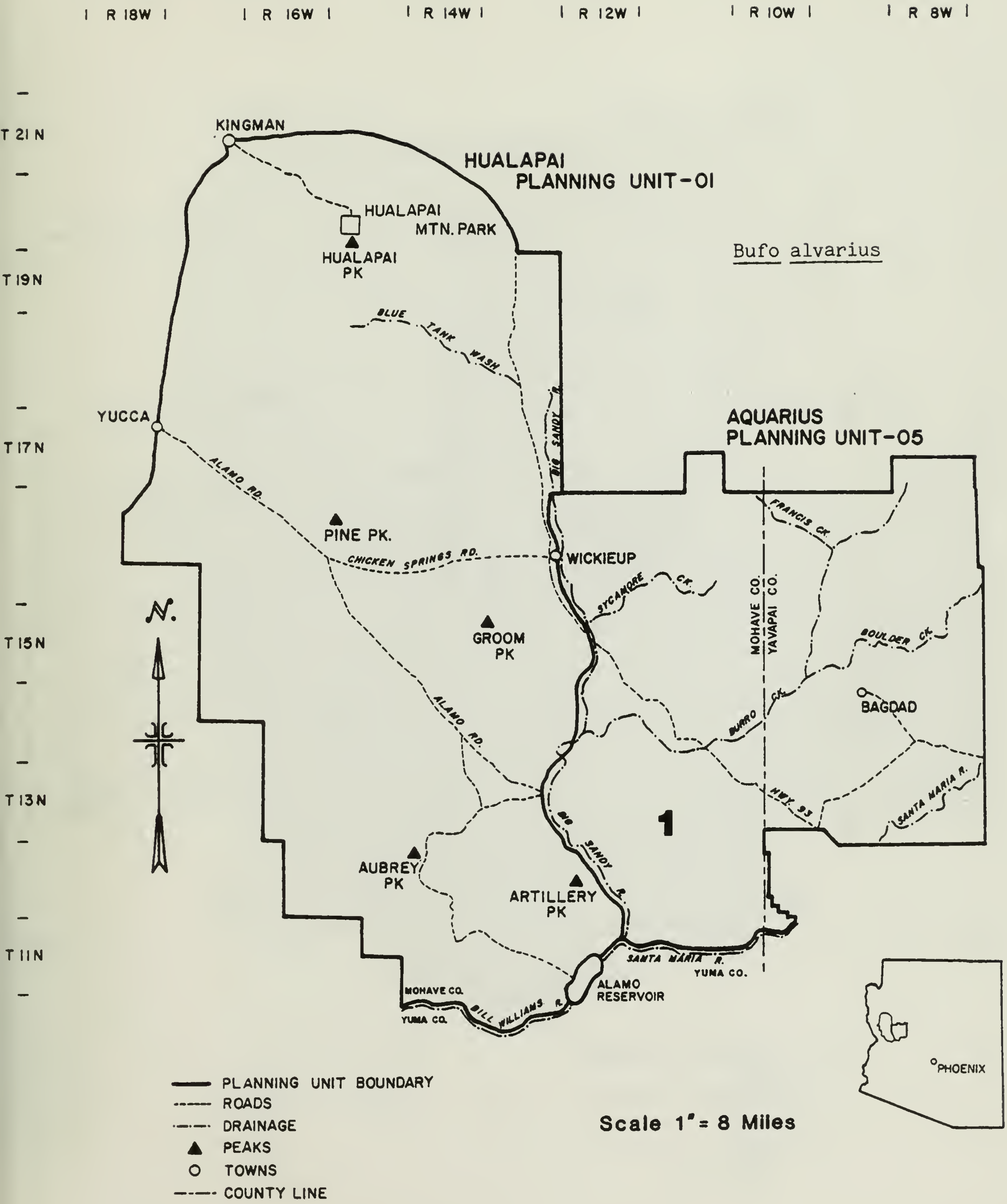
APPENDIX 2 (CONT'D)

Scientific Name		Common Name Index
Masticophis taeniatus	-	Striped Whipsnake
Phyllorhynchus decurtatus	-	Spotted Leaf-nose Snake
Pituophis melanoleucus	-	Gopher Snake
Rhinocheilus leconti	-	Long-nosed Snake
Salvadora hexalepis	-	Western Patch-nosed Snake
Sonora semiannulata	-	Western Ground Snake
Tantilla p. atriceps	-	Mexican Black-headed Snake
Thamnophis cyrtopsis	-	Black-necked Garter Snake
Thamnophis marcianus	-	Checkered Garter Snake
Trimorphodon b. lambda	-	Lyre Snake
Crotalus atrox	-	Western Diamondback Rattlesnake
Crotalus cerastes	-	Sidewinder
Crotalus mitchelli	-	Speckled Rattlesnake
Crotalus molossus	-	Black-tailed Rattlesnake
Crotalus scutulatus	-	Mohave Rattlesnake
Crotalus v. cerberus	-	Arizona Black Rattlesnake
Micruroides euryxanthus	-	Coral Snake
Leptotyphlops humilis	-	Western Blind Snake

Appendix 3. - Distributions and type localities for reptiles and amphibians of the Hualapai-Aquarius planning area. Numbers indicate type localities on file at the Phoenix District, Phoenix, Arizona. Areas cross-hatched indicate estimated herpetofauna distributions based on habitat associations and distribution. Pages 68-128



Scaphiopus couchi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PLANNING UNIT BOUNDARY
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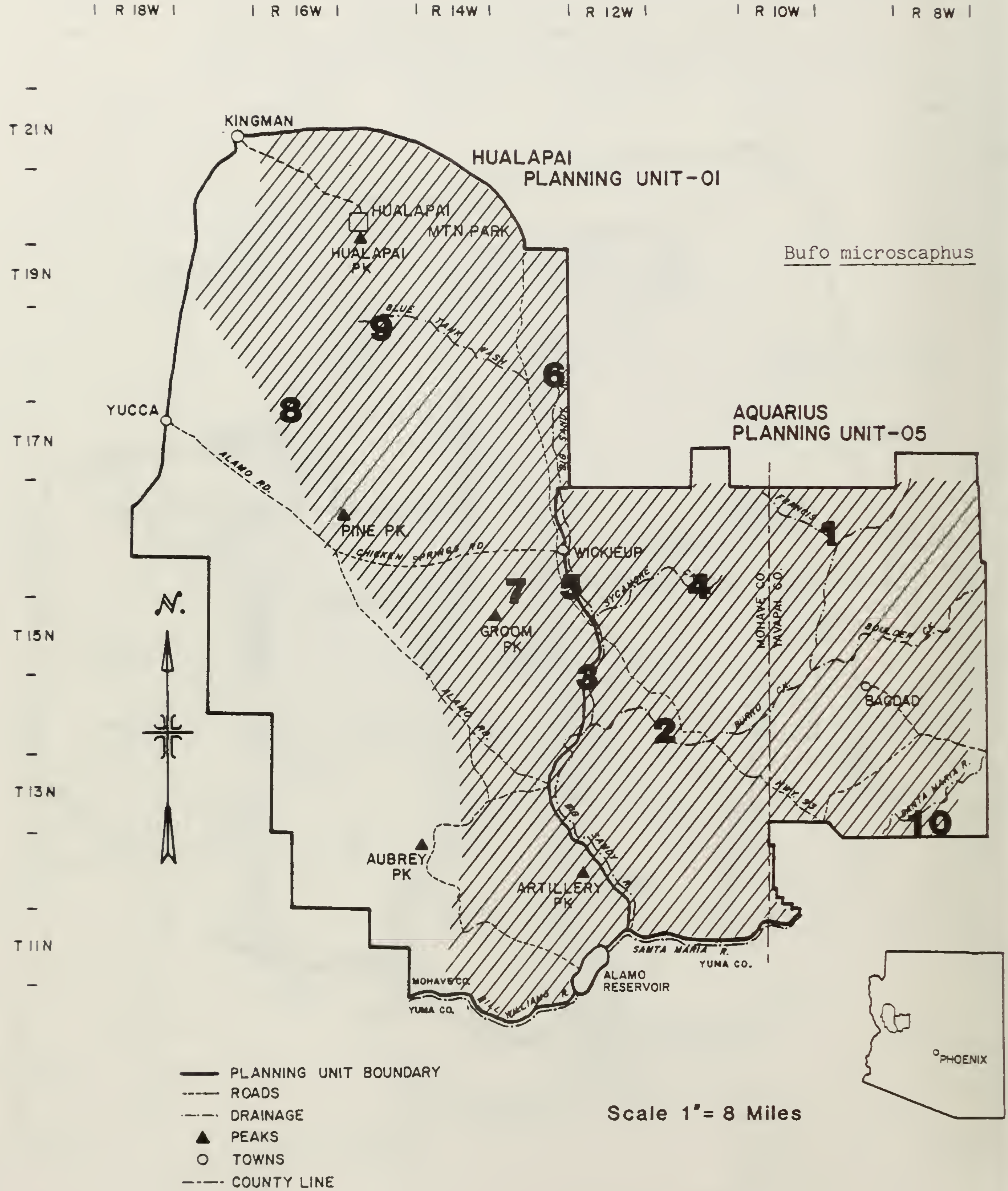
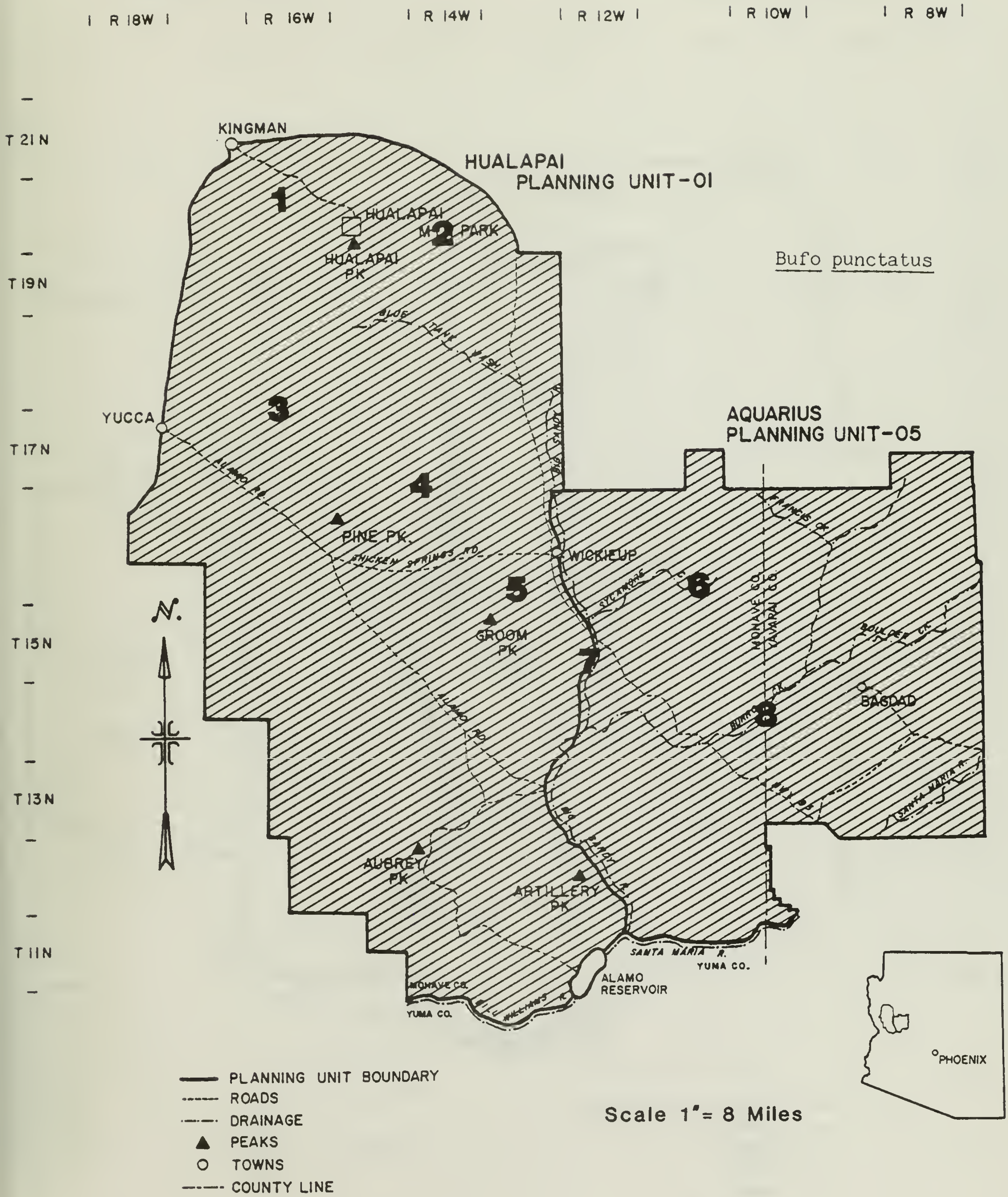
PEAKS
TOWNS
COUNTY LINE
Scale 1" = 8 Miles

APPENDIX 3 (CONT'D)

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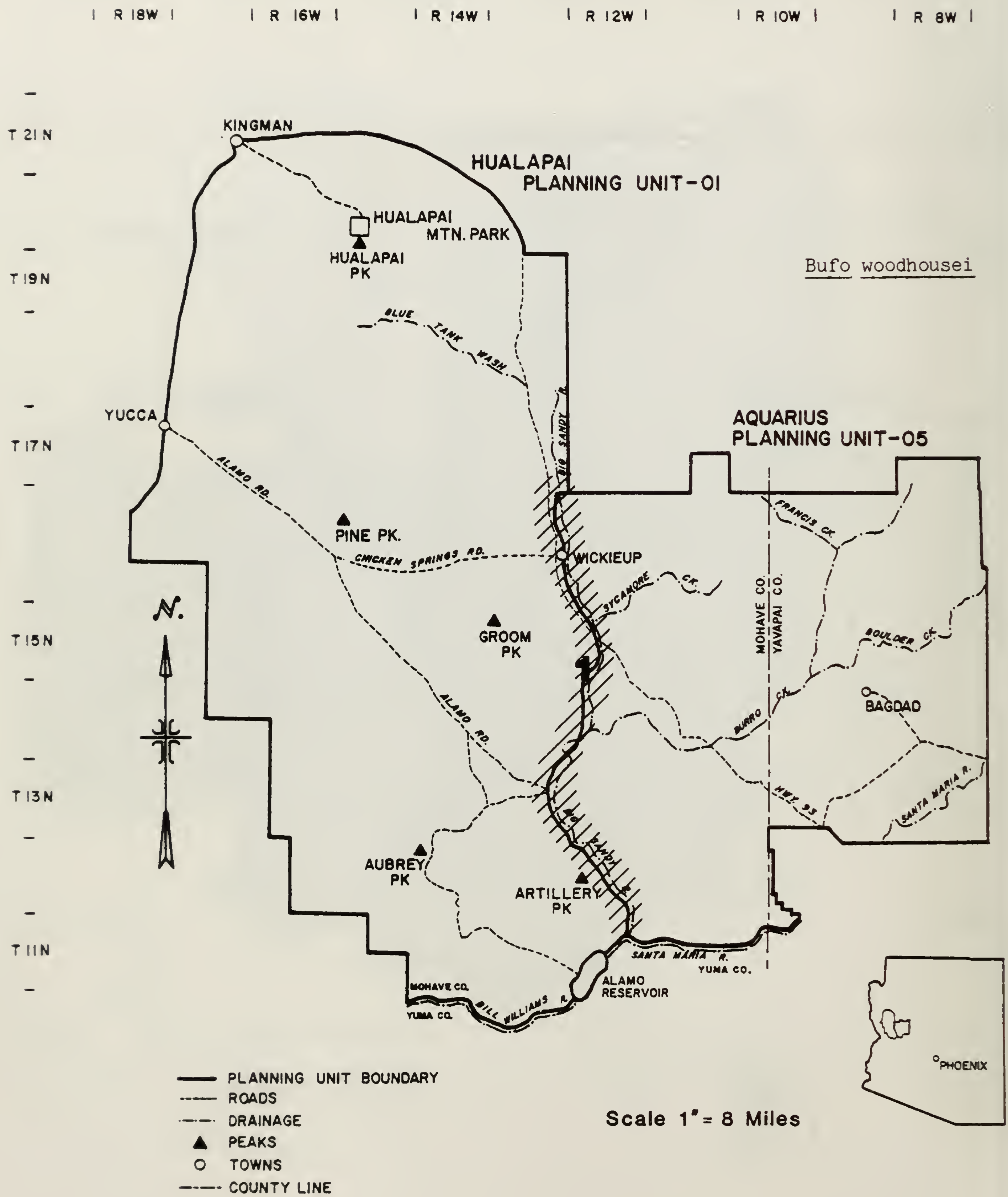
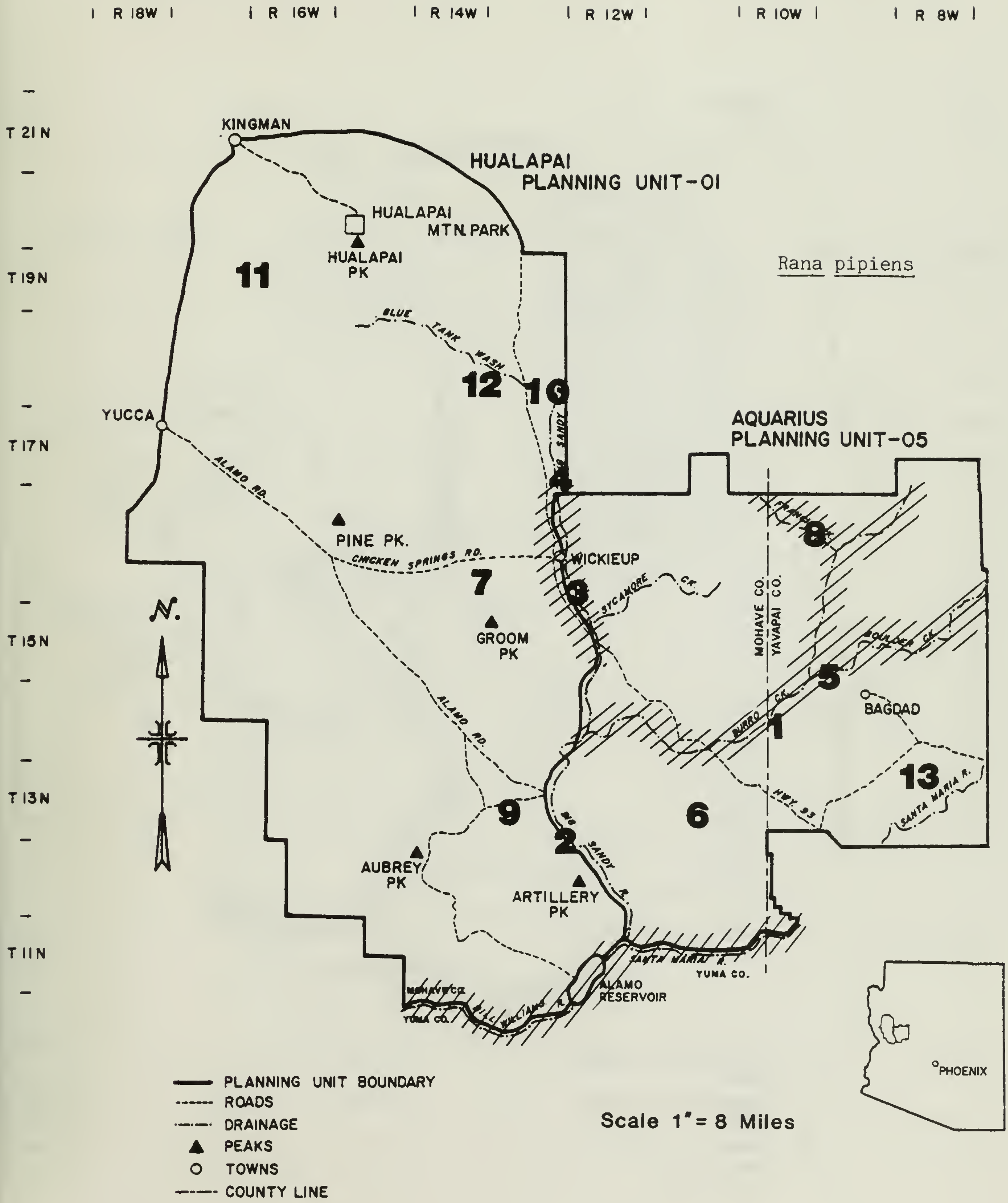


Bufo woodhousei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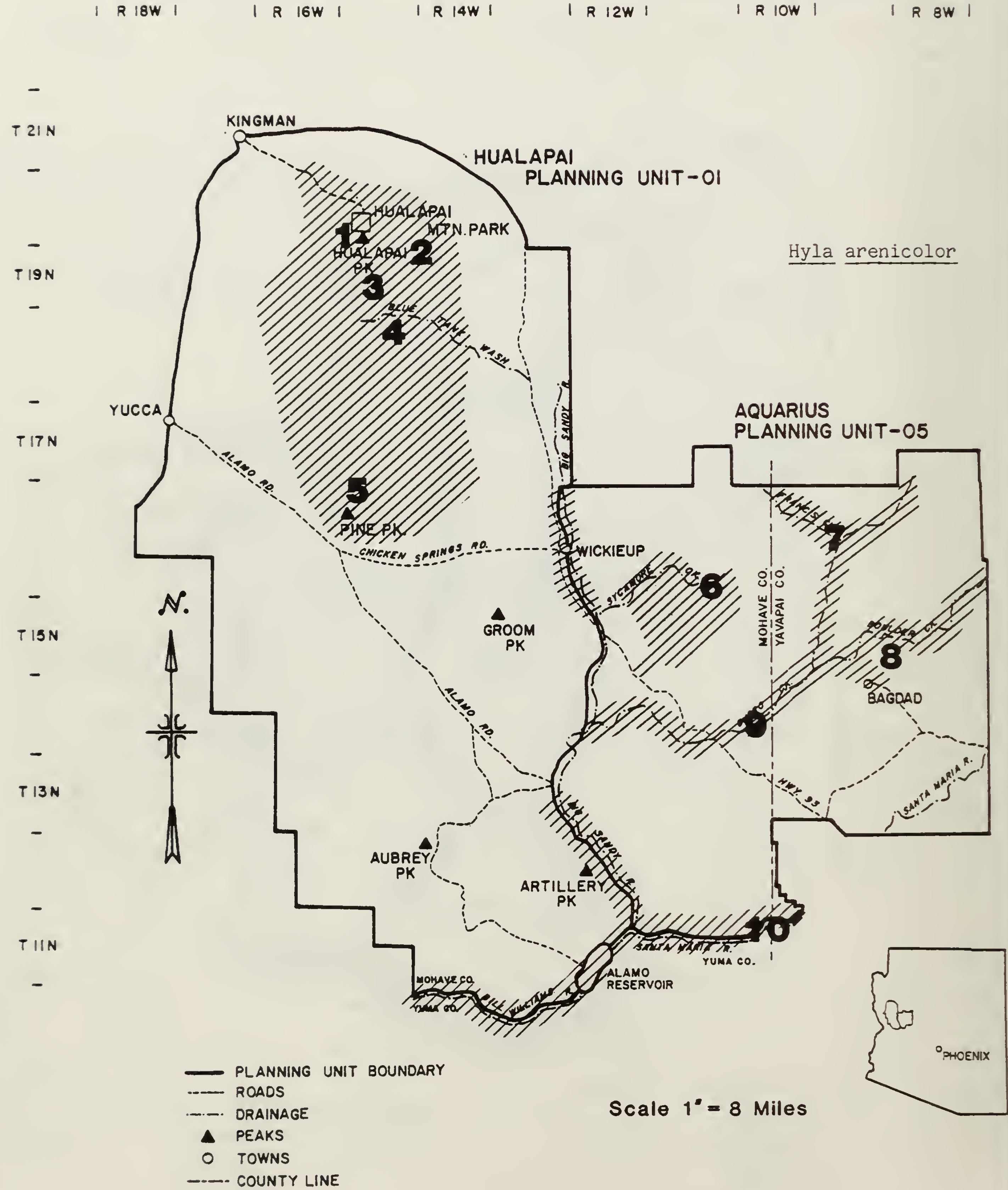
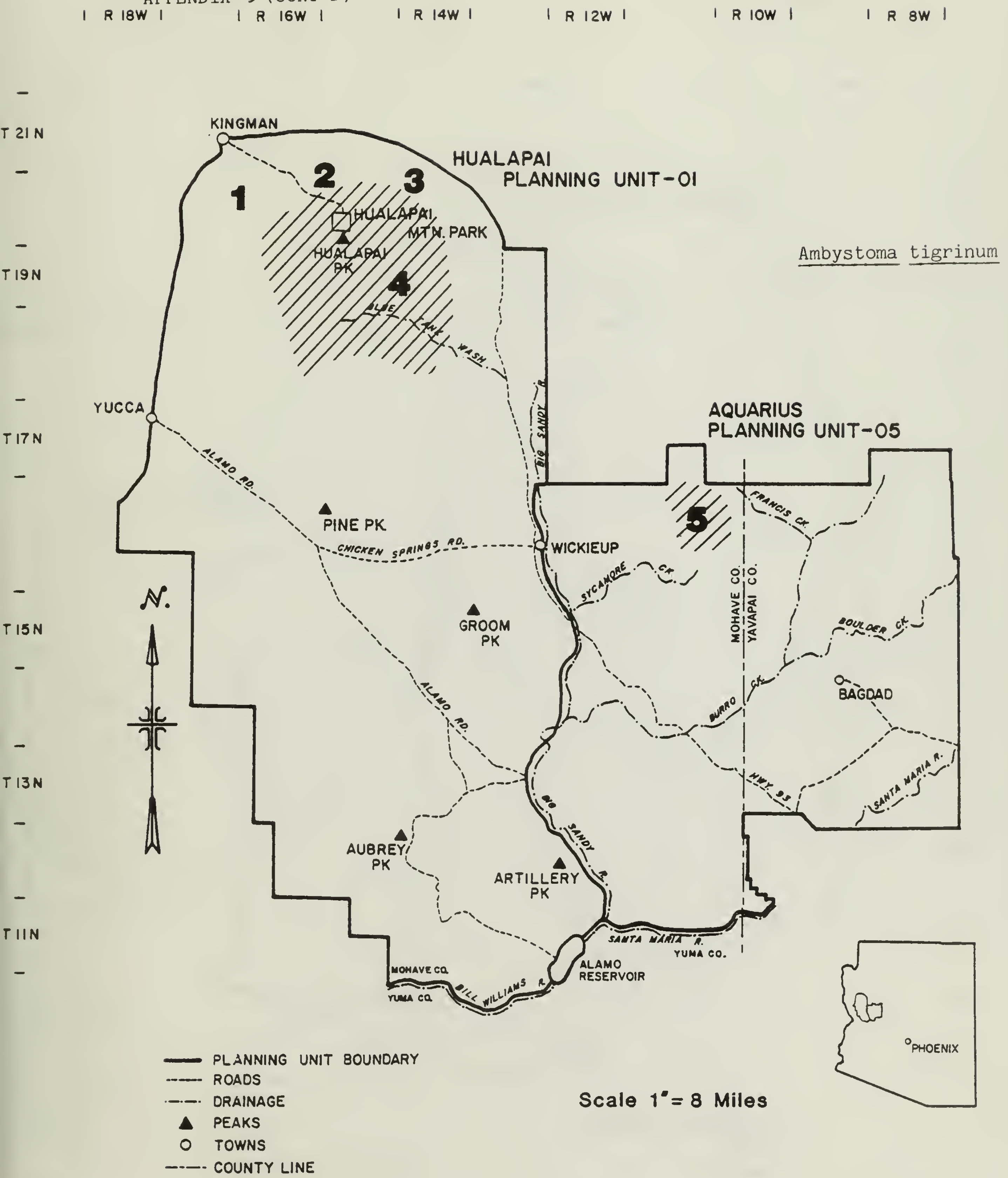
APPENDIX 3 (CONT'D)





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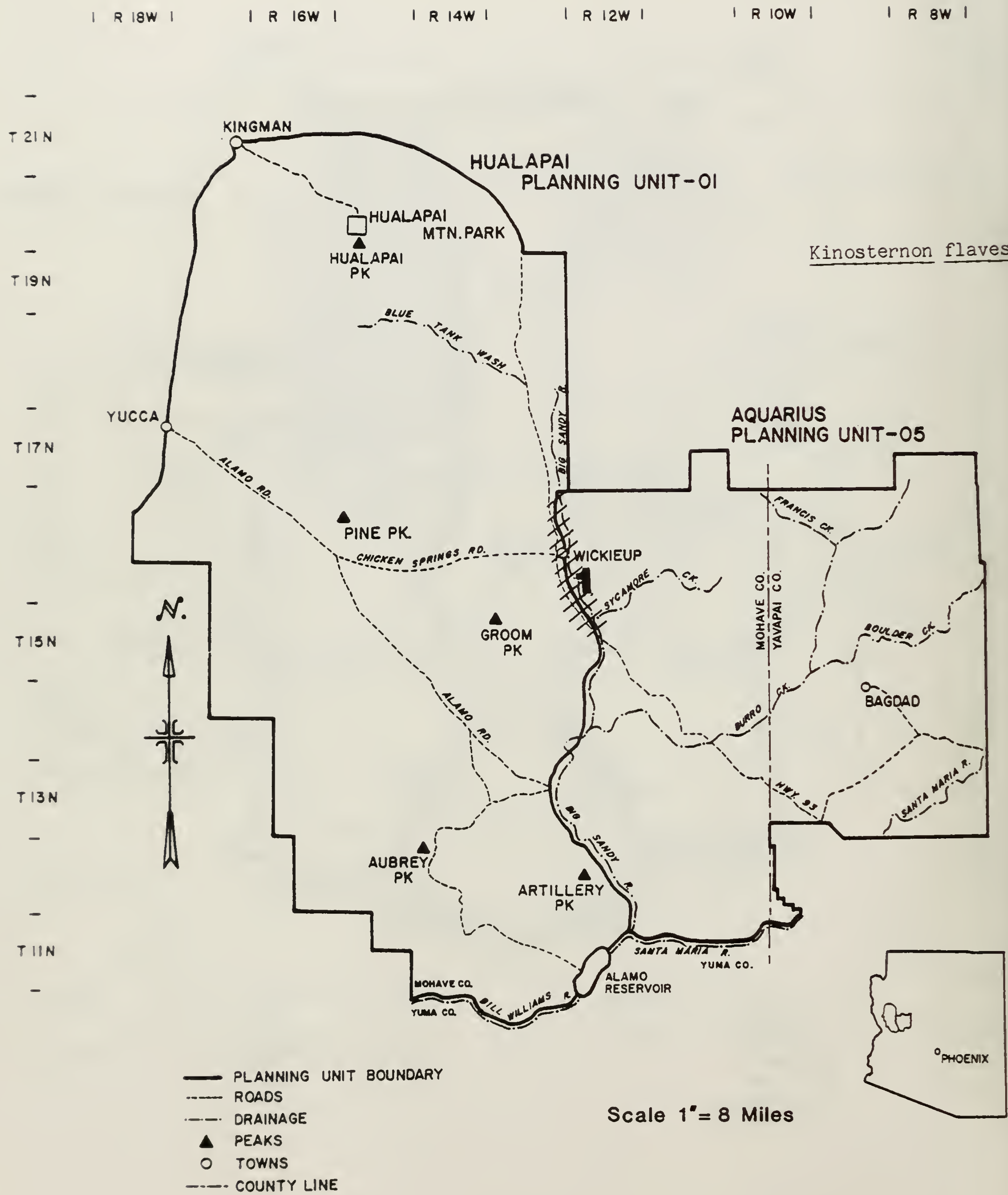
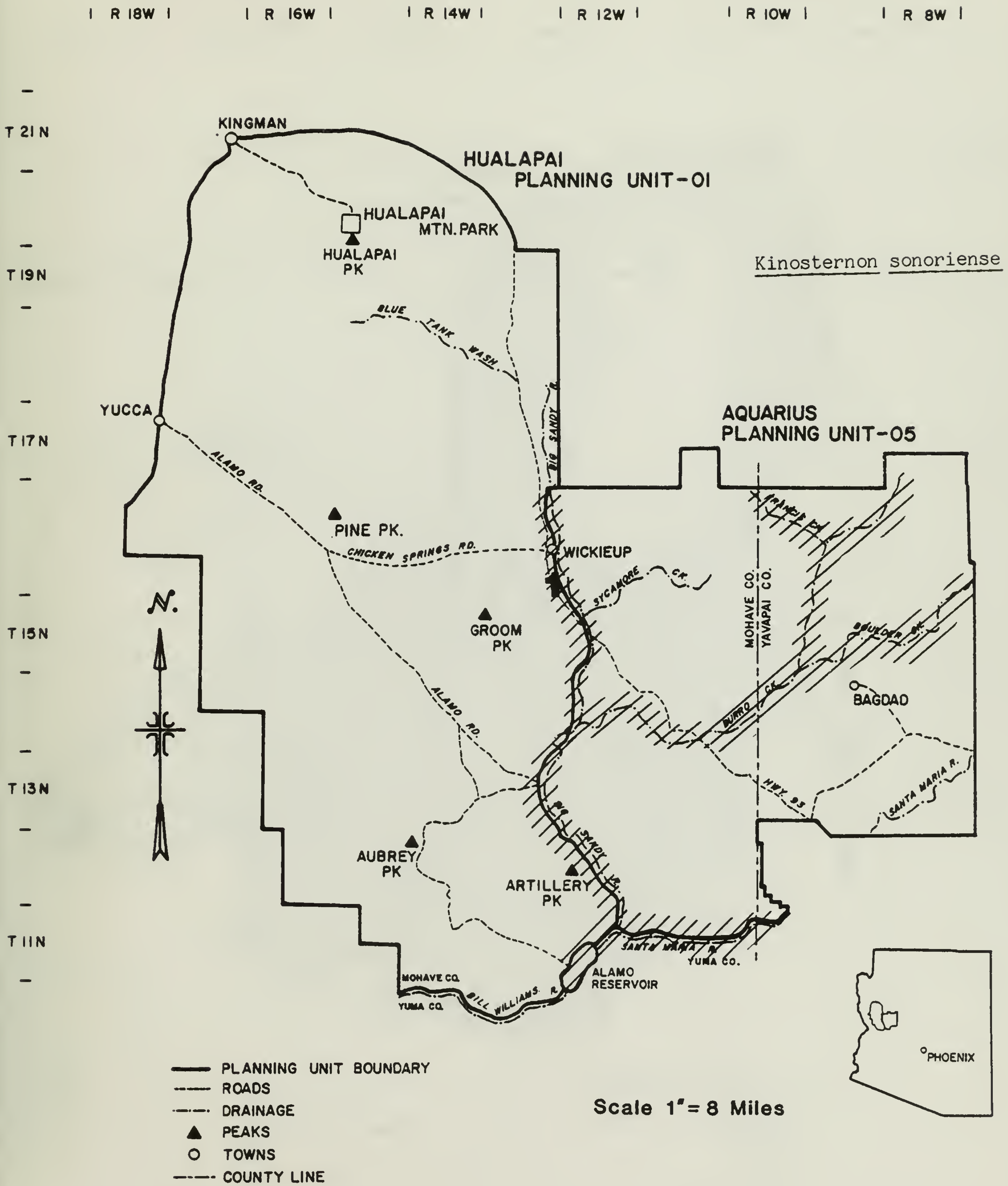


Kinosternon flavescer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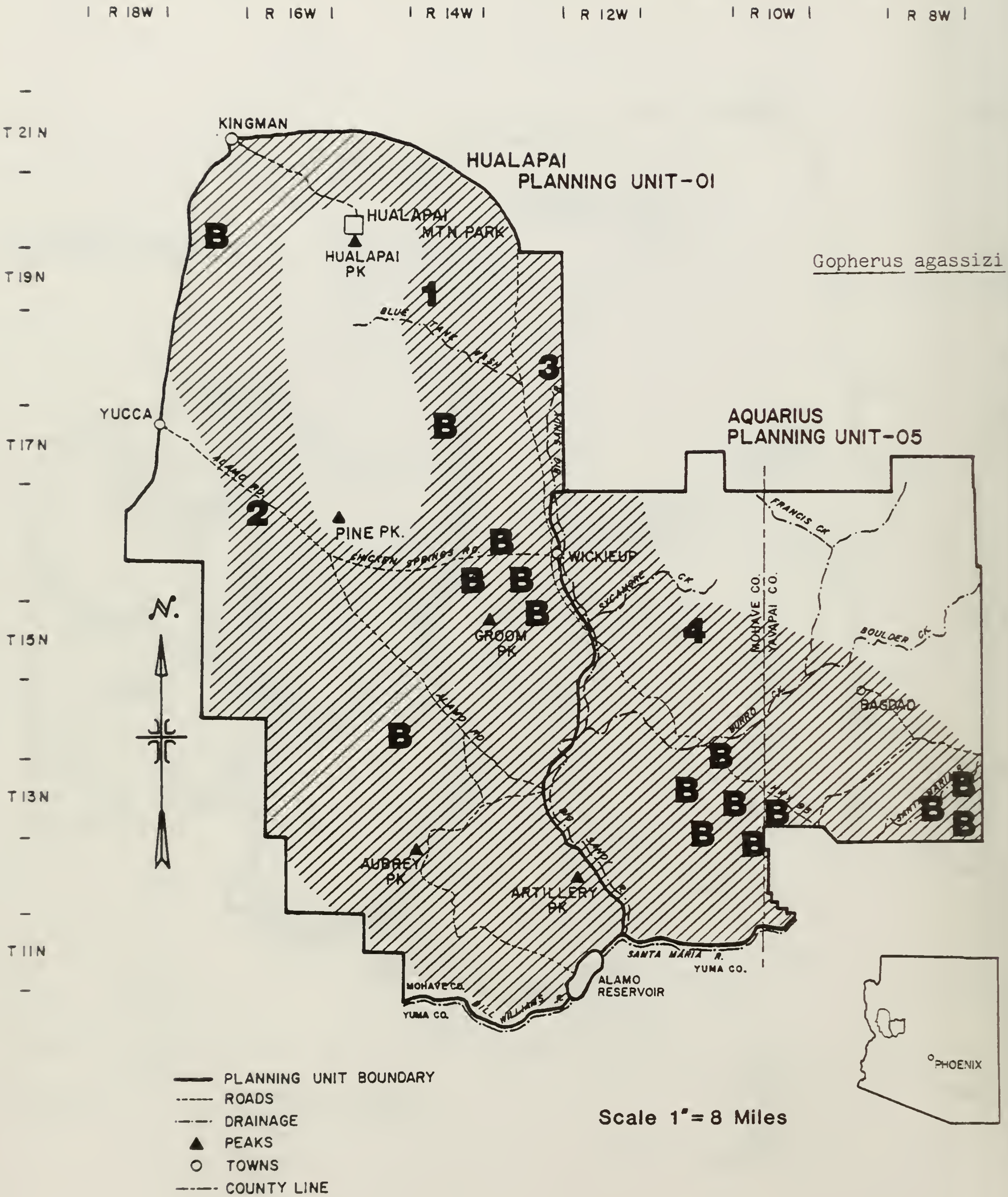
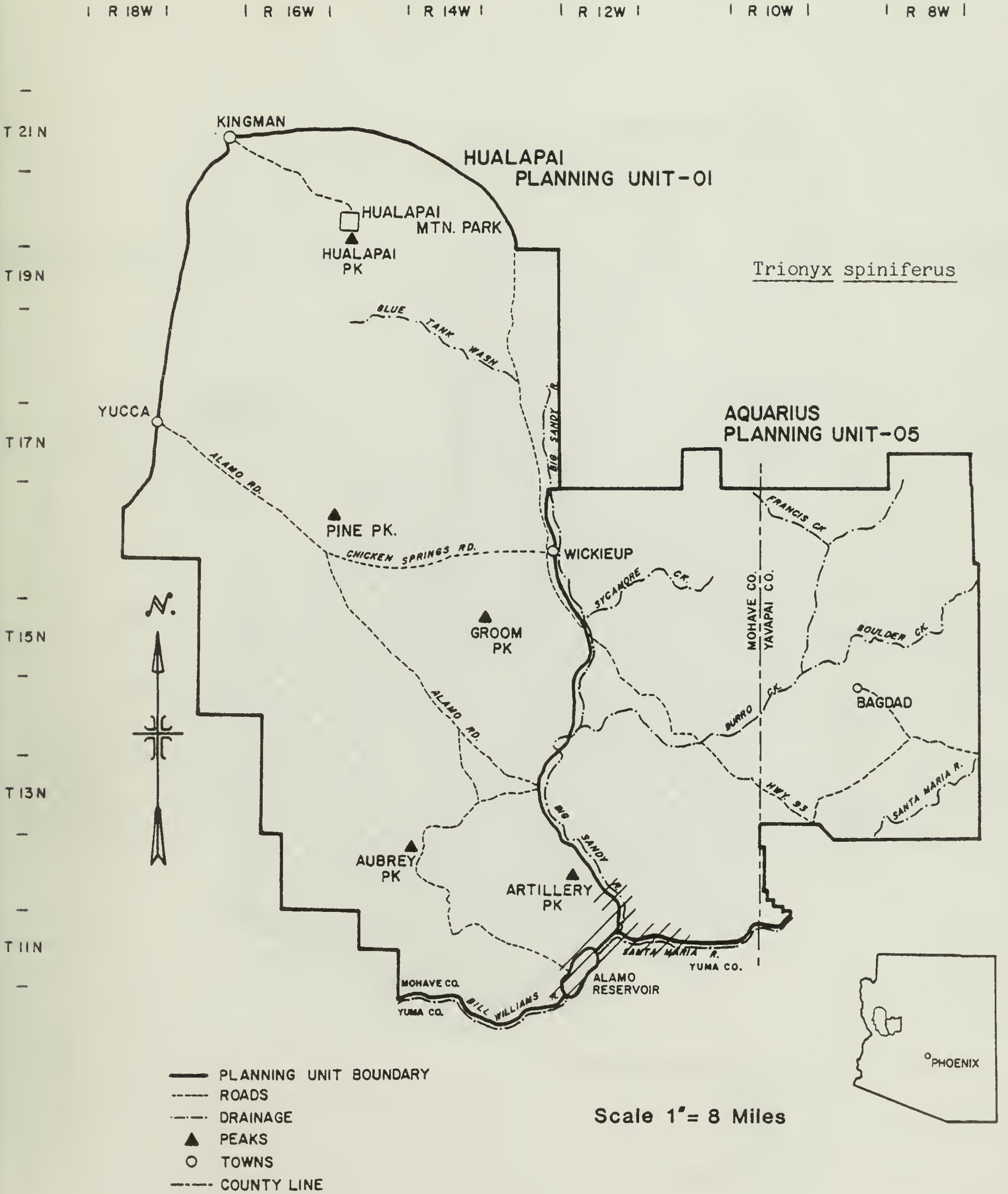
Gopherus agassizi





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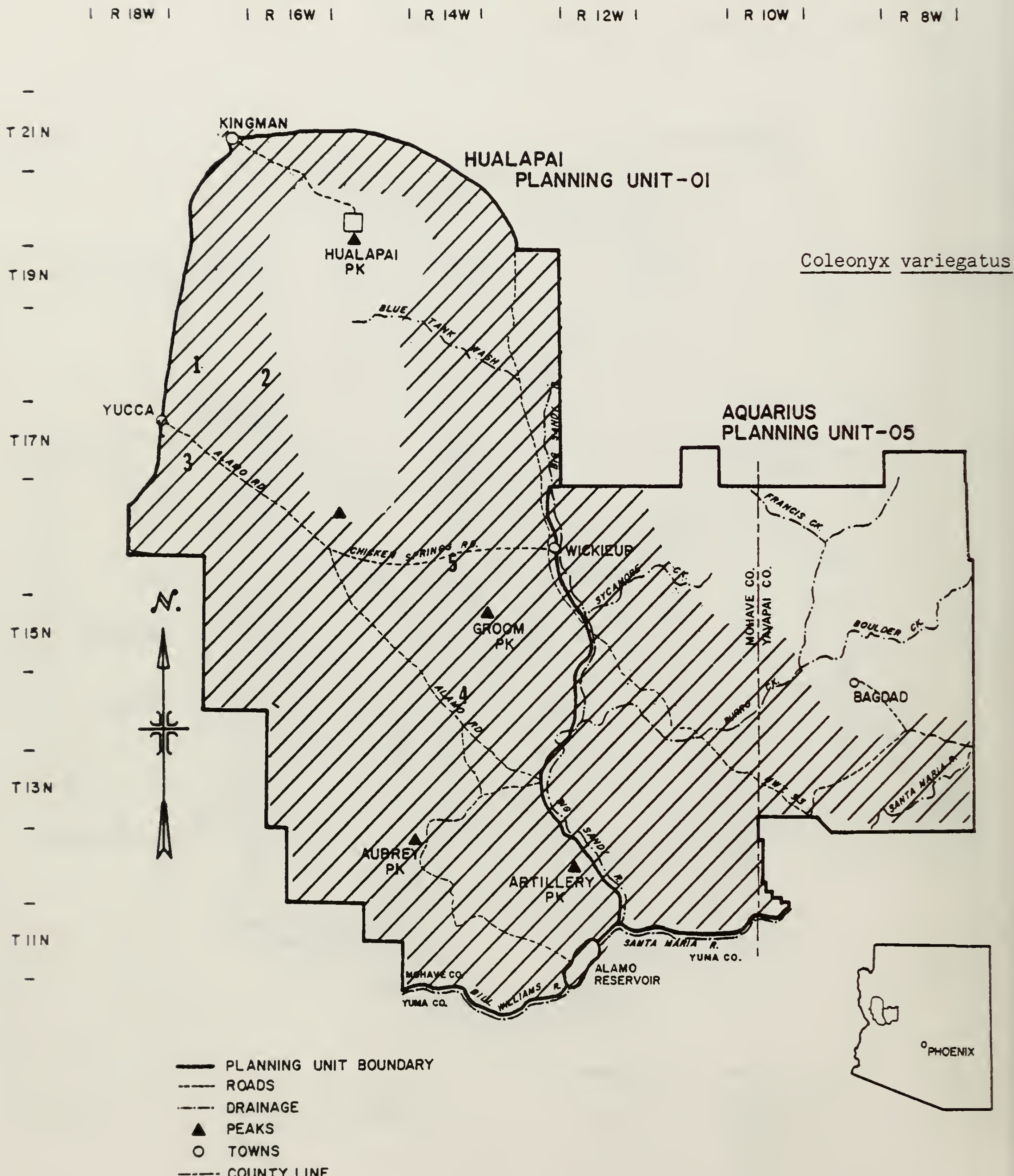

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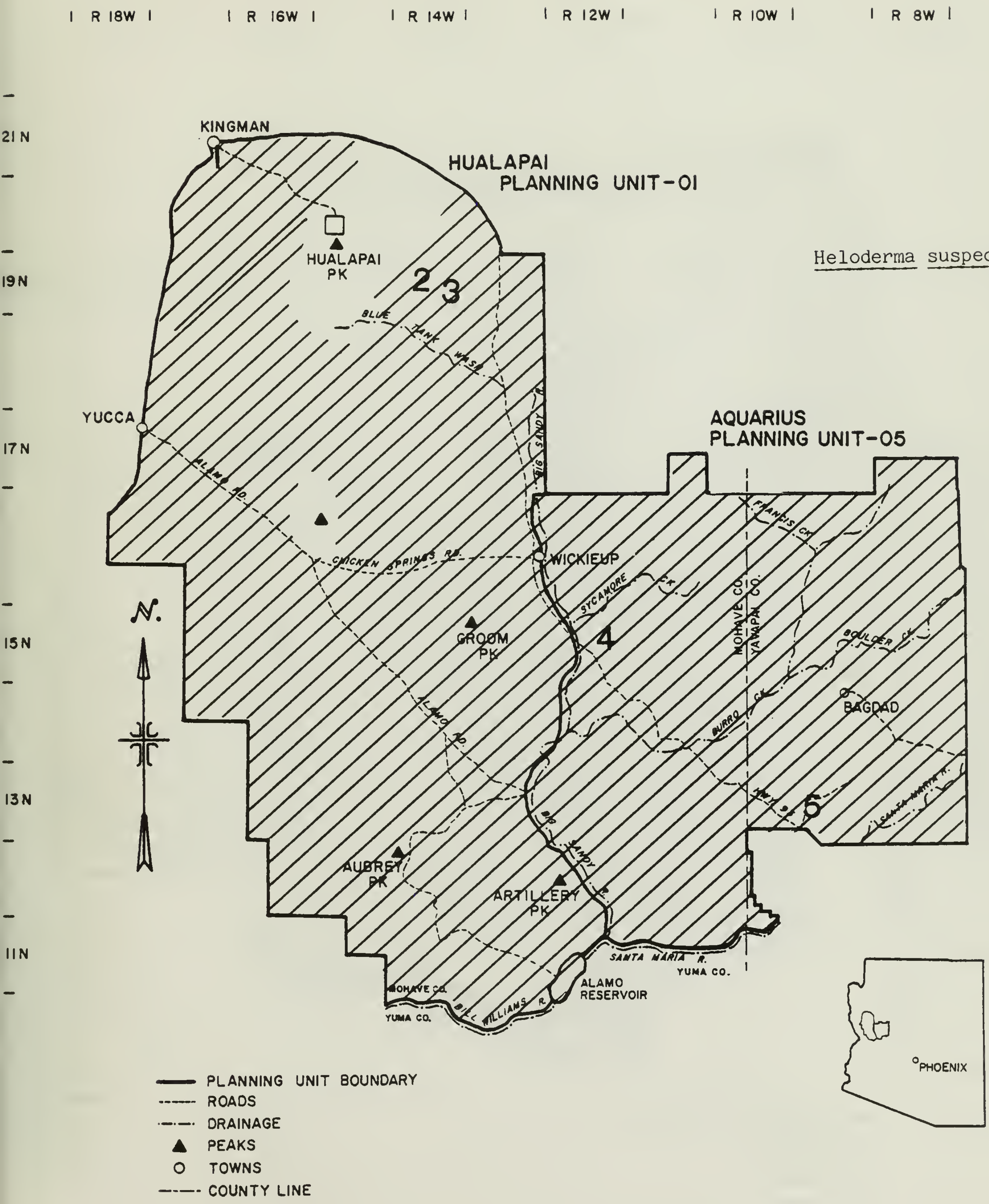
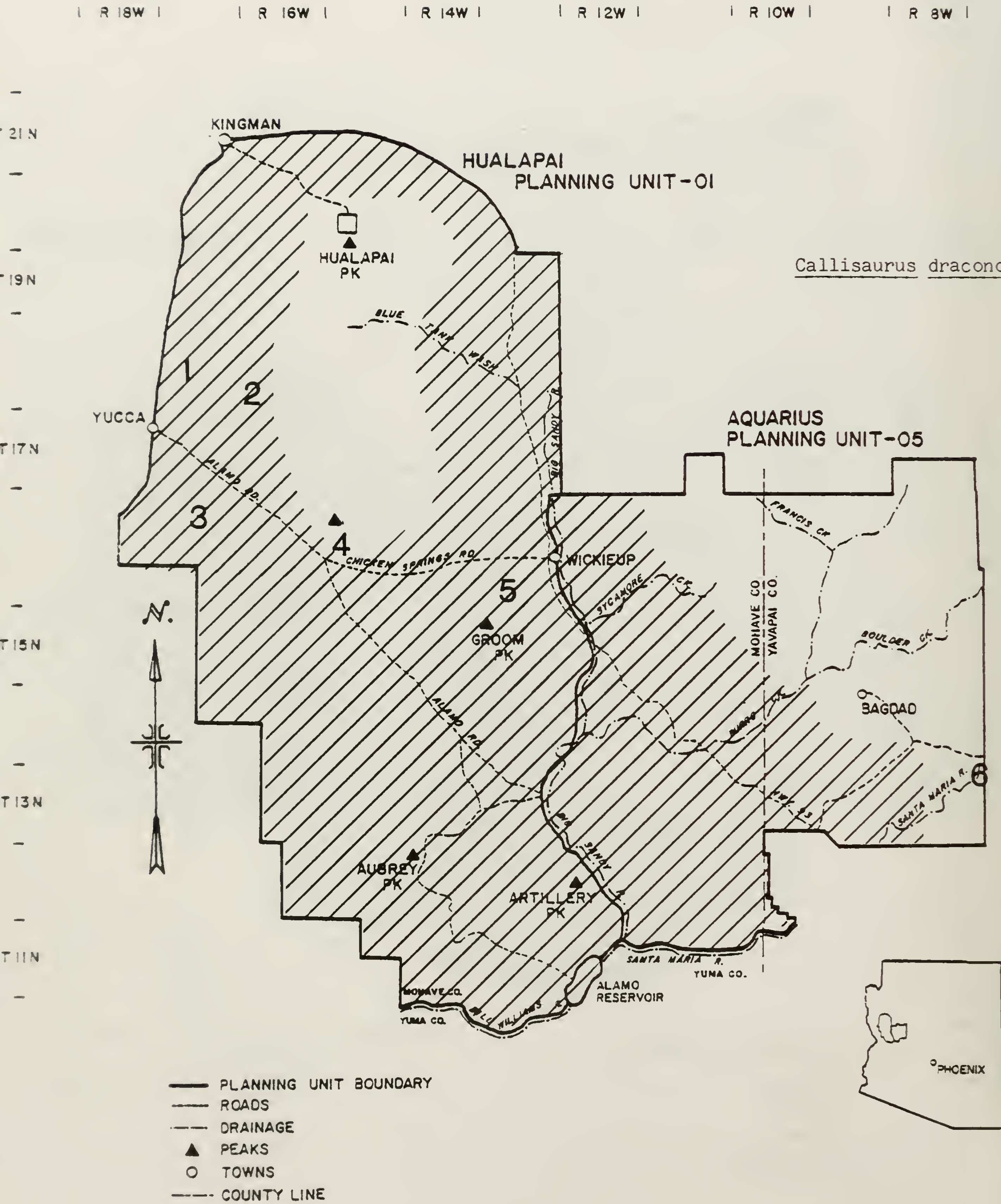
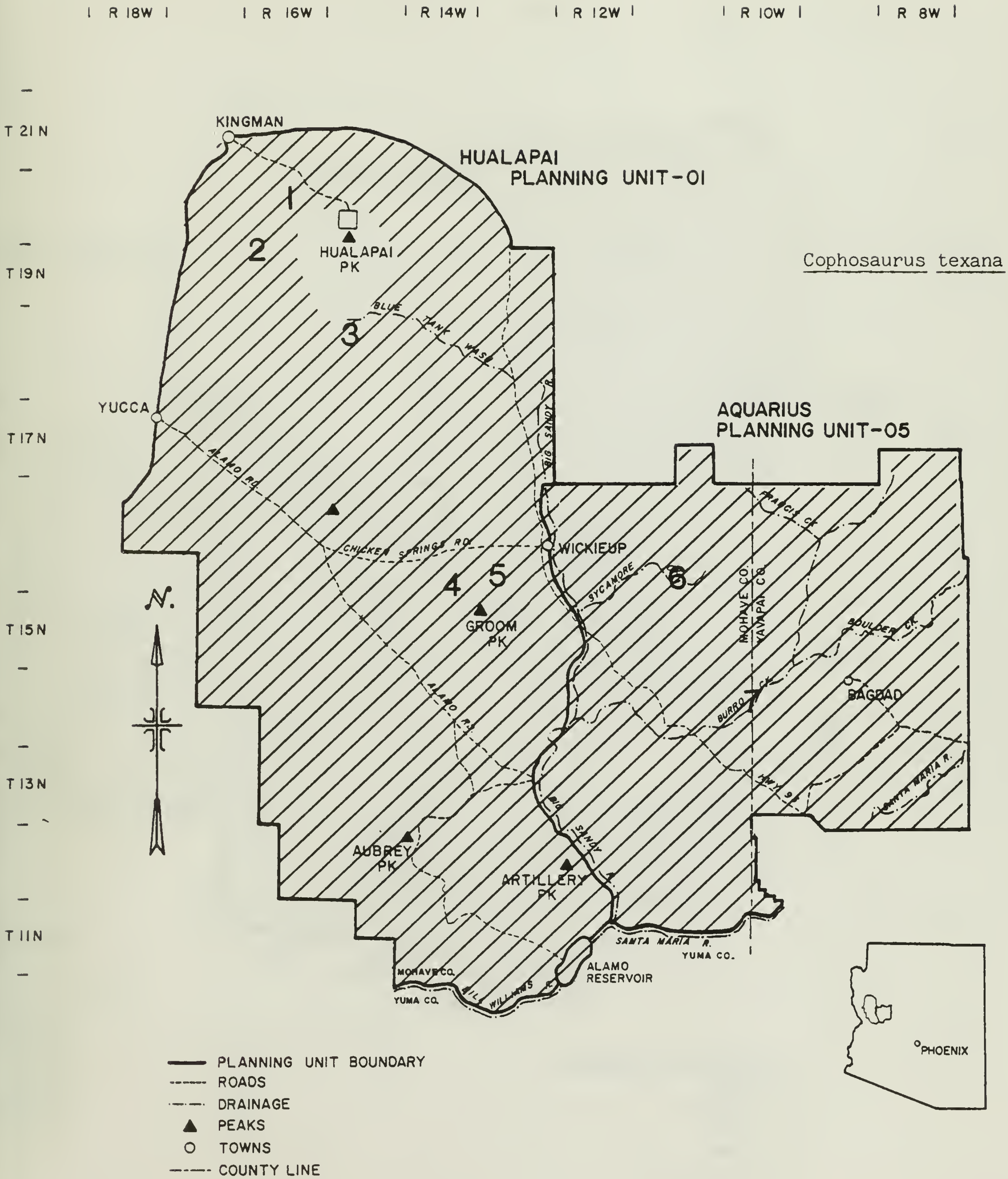


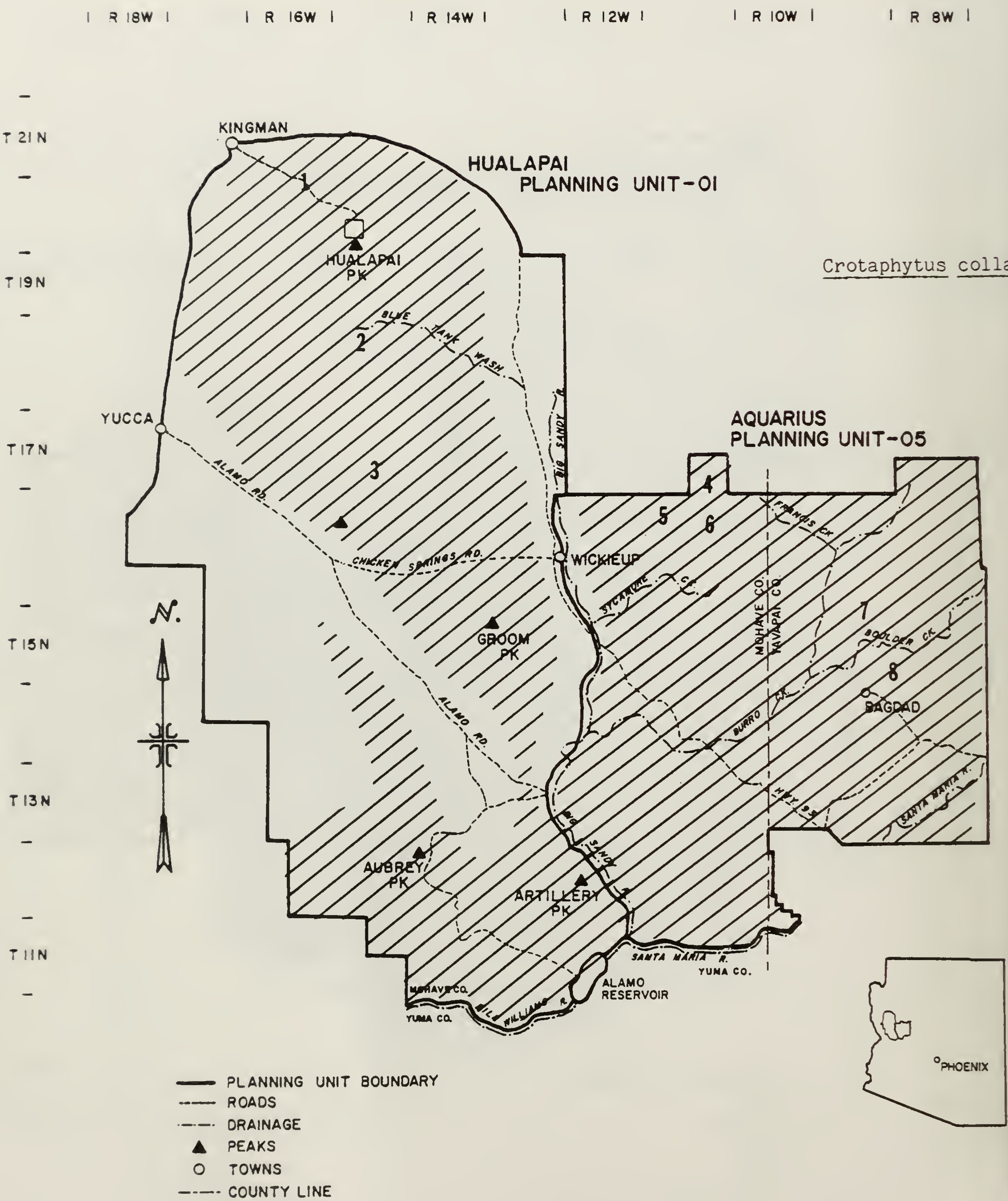
Heloderma suspectum



Callisaurus draconoides

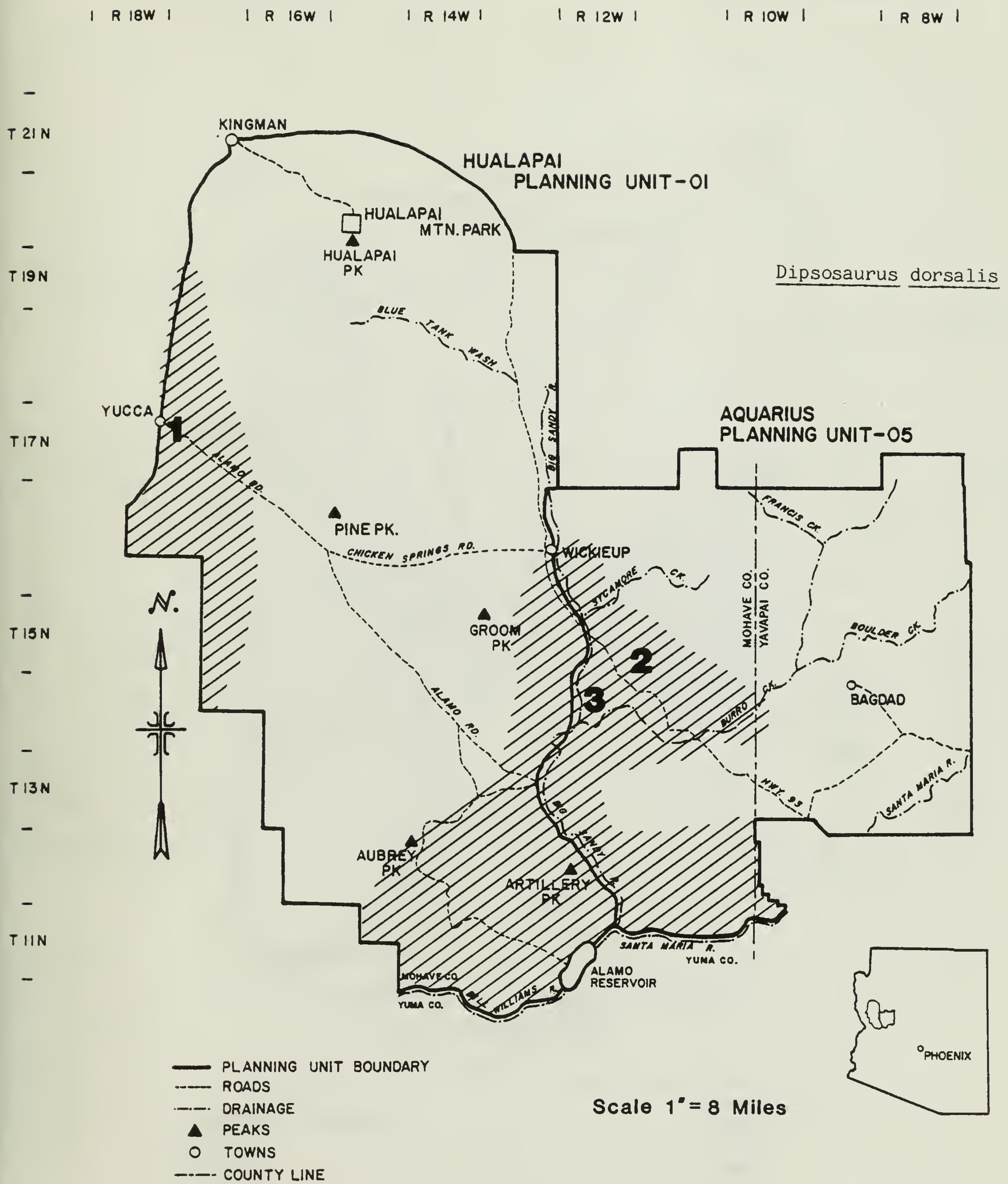
<u>Cophosaurus</u> <u>texana</u>

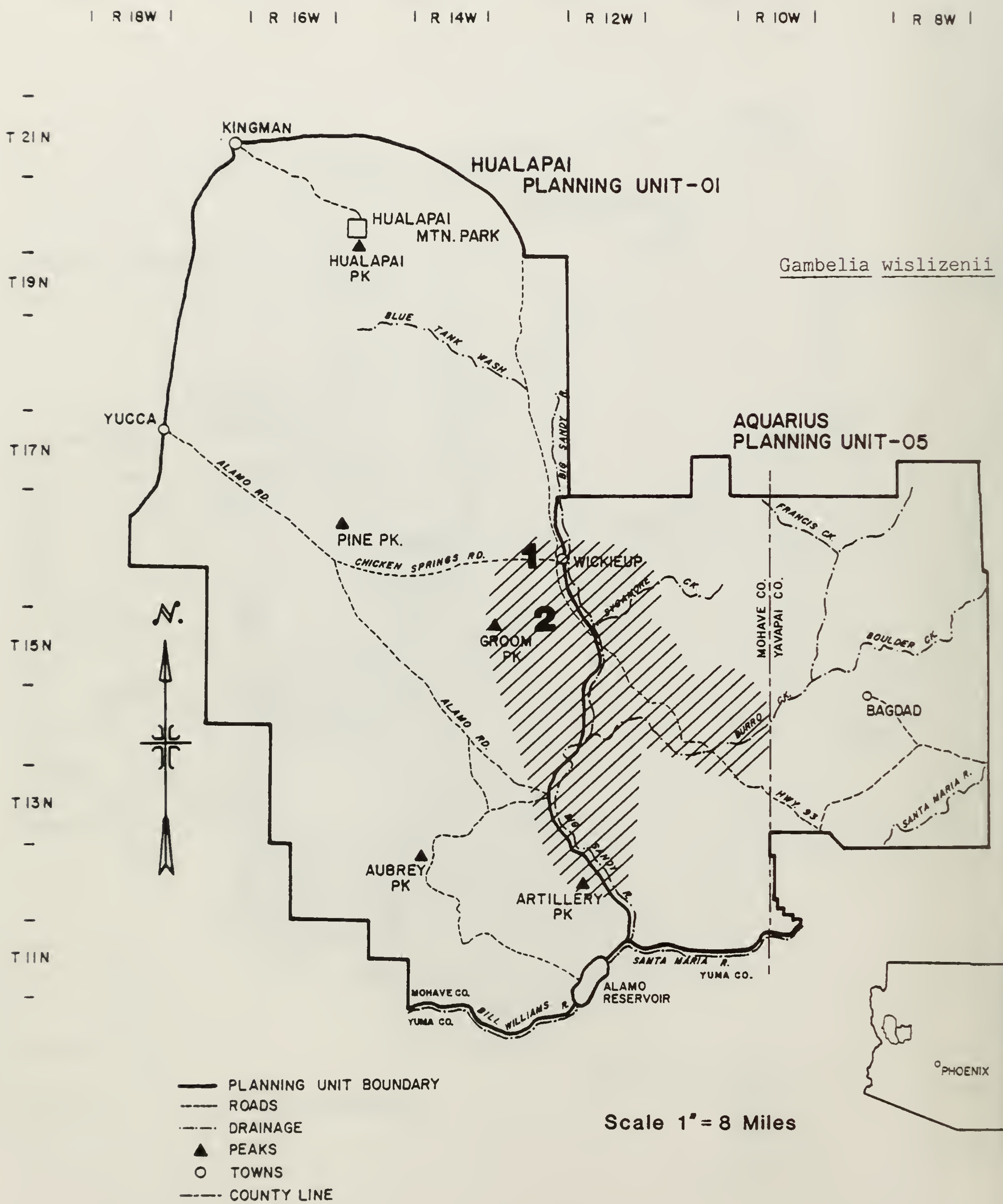




Crotaphytus collari:

Dipsosaurus dorsalis





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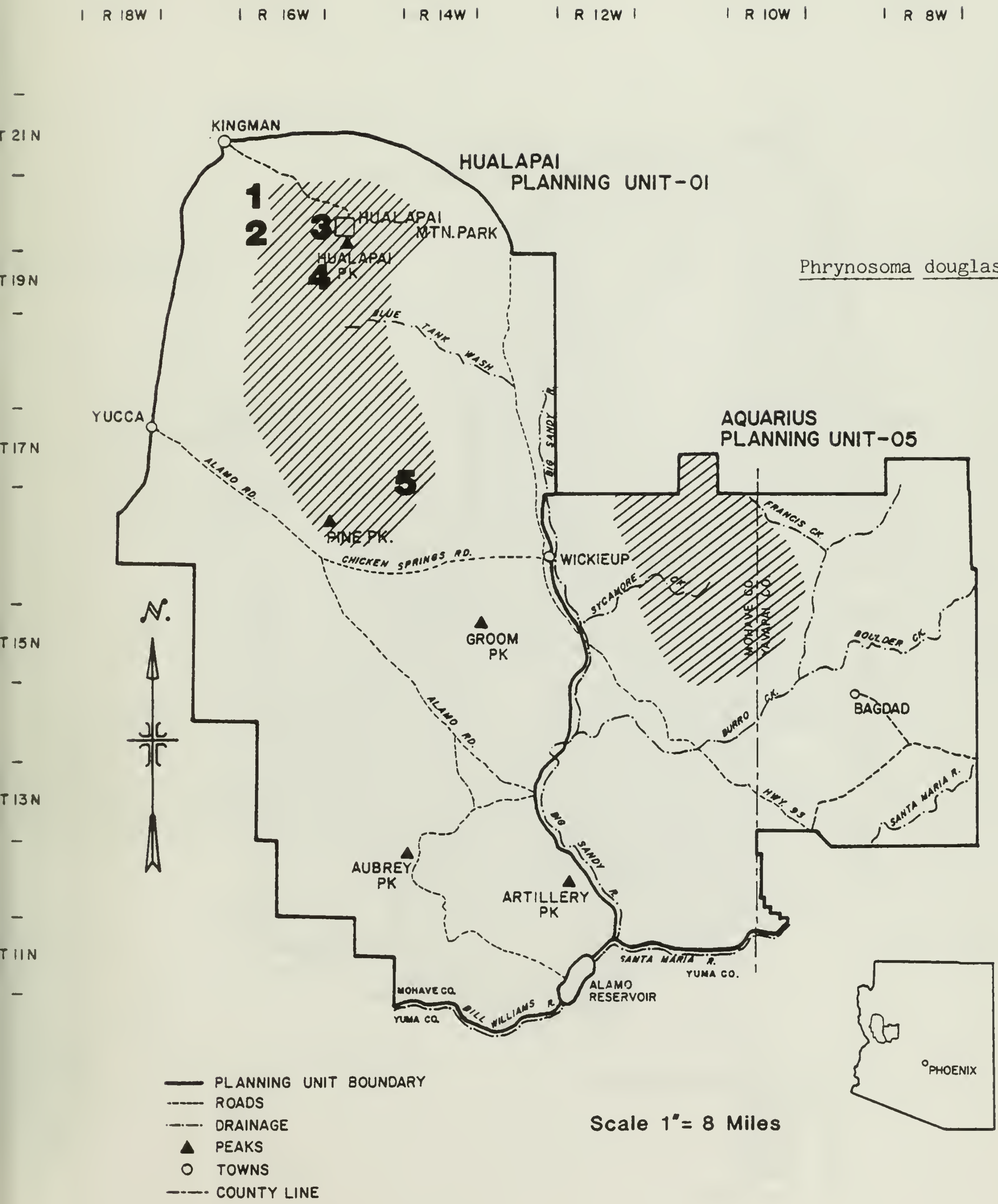
Phrynosoma douglassi



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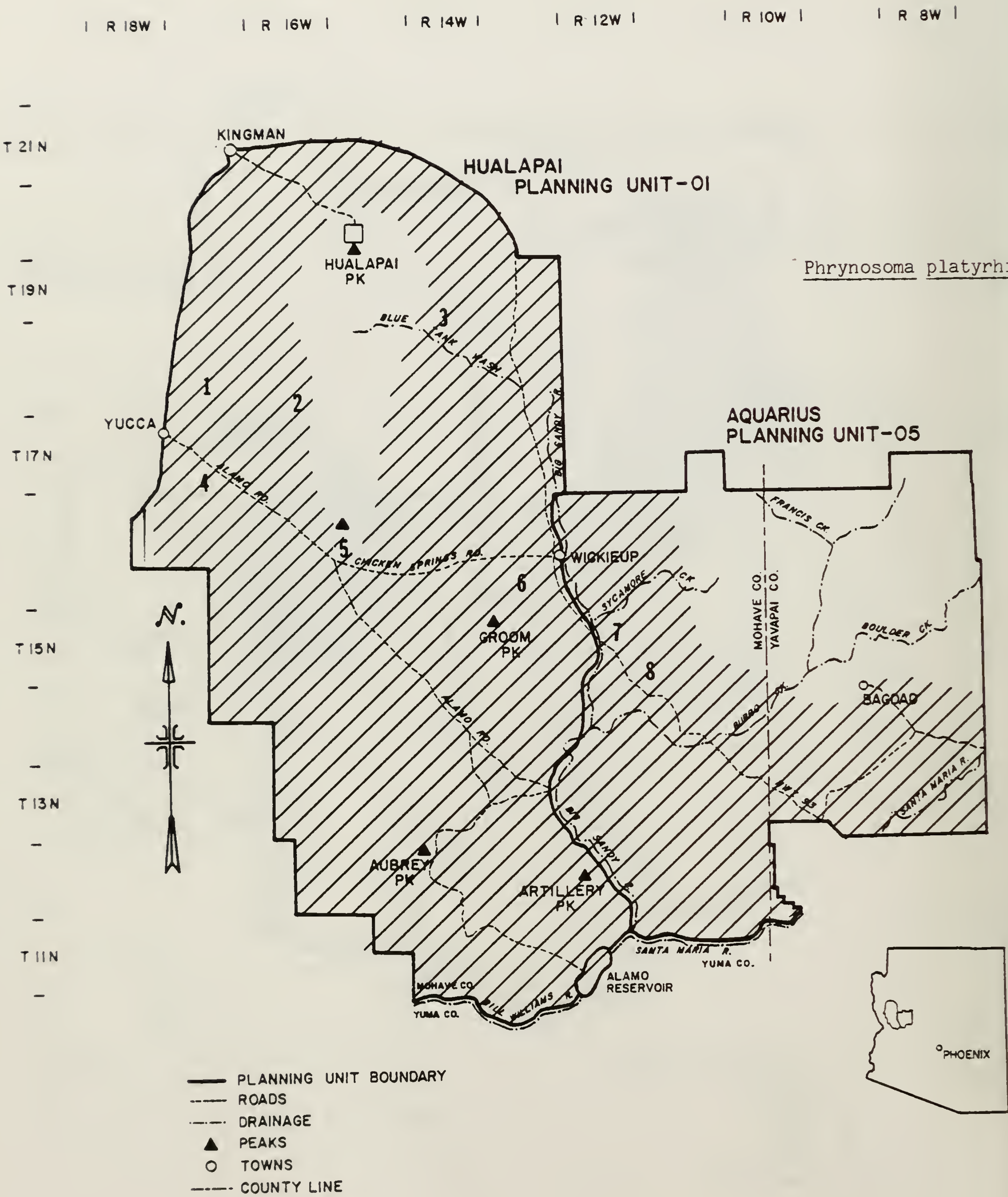
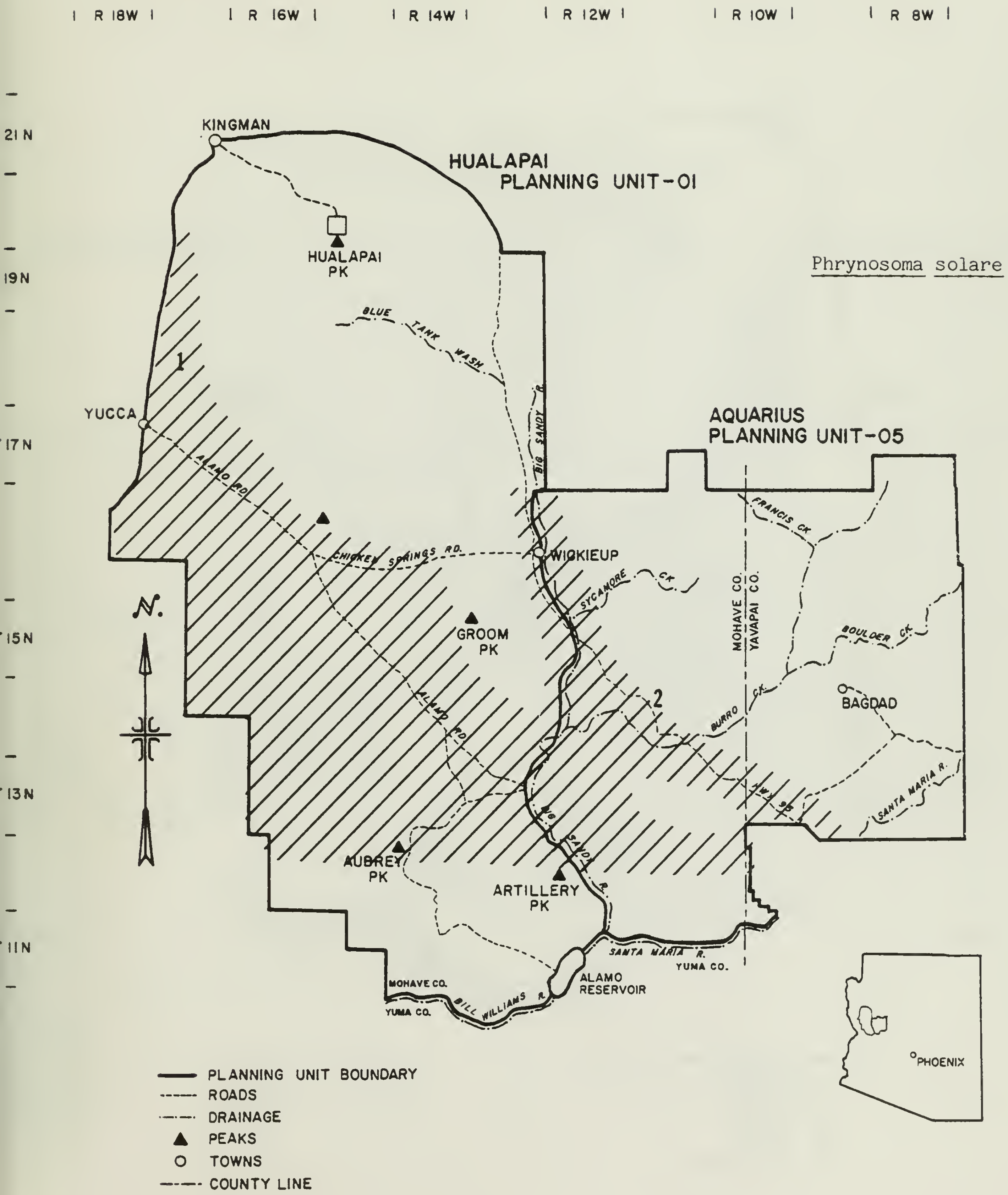


Phrynosoma platyrhinc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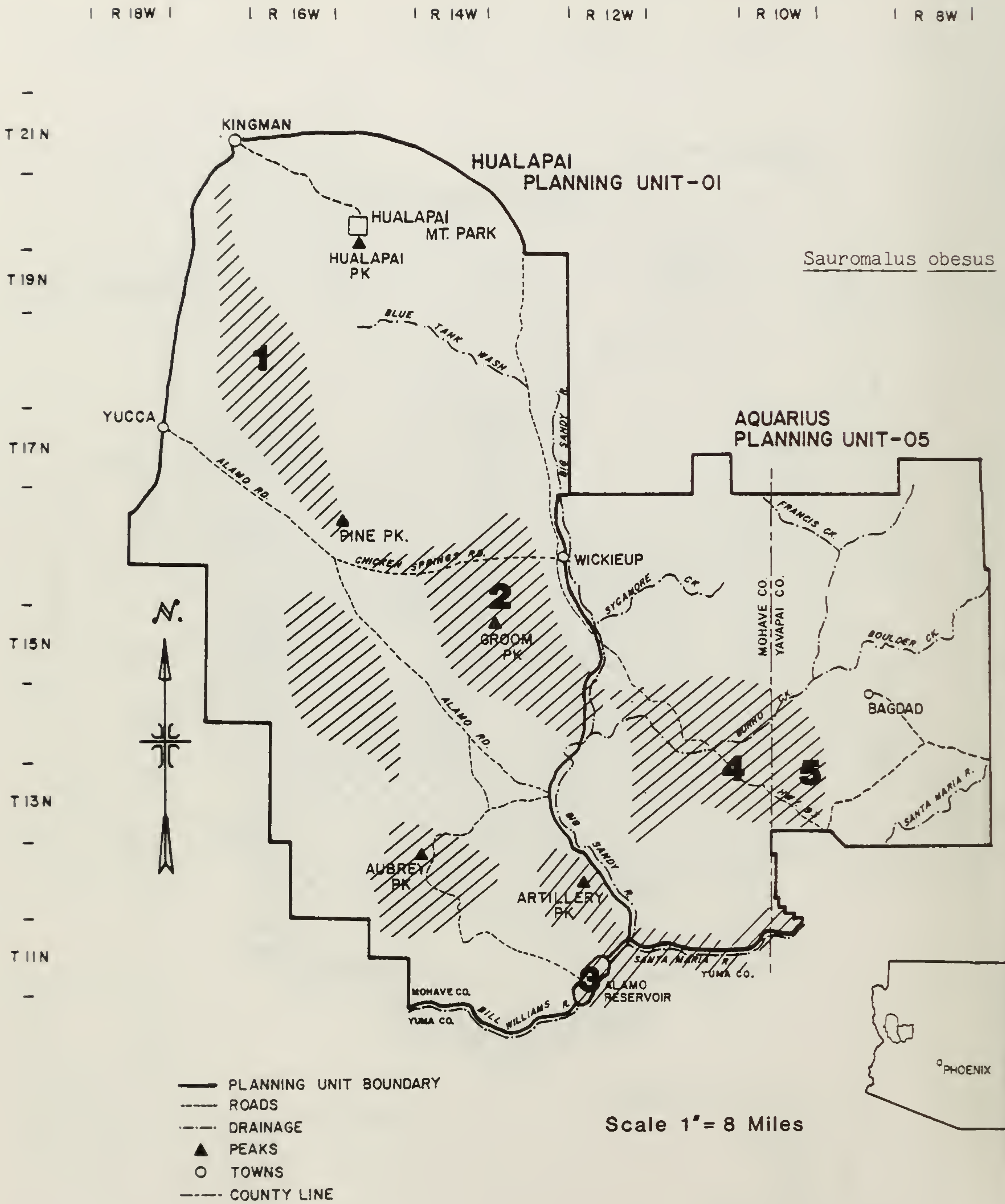
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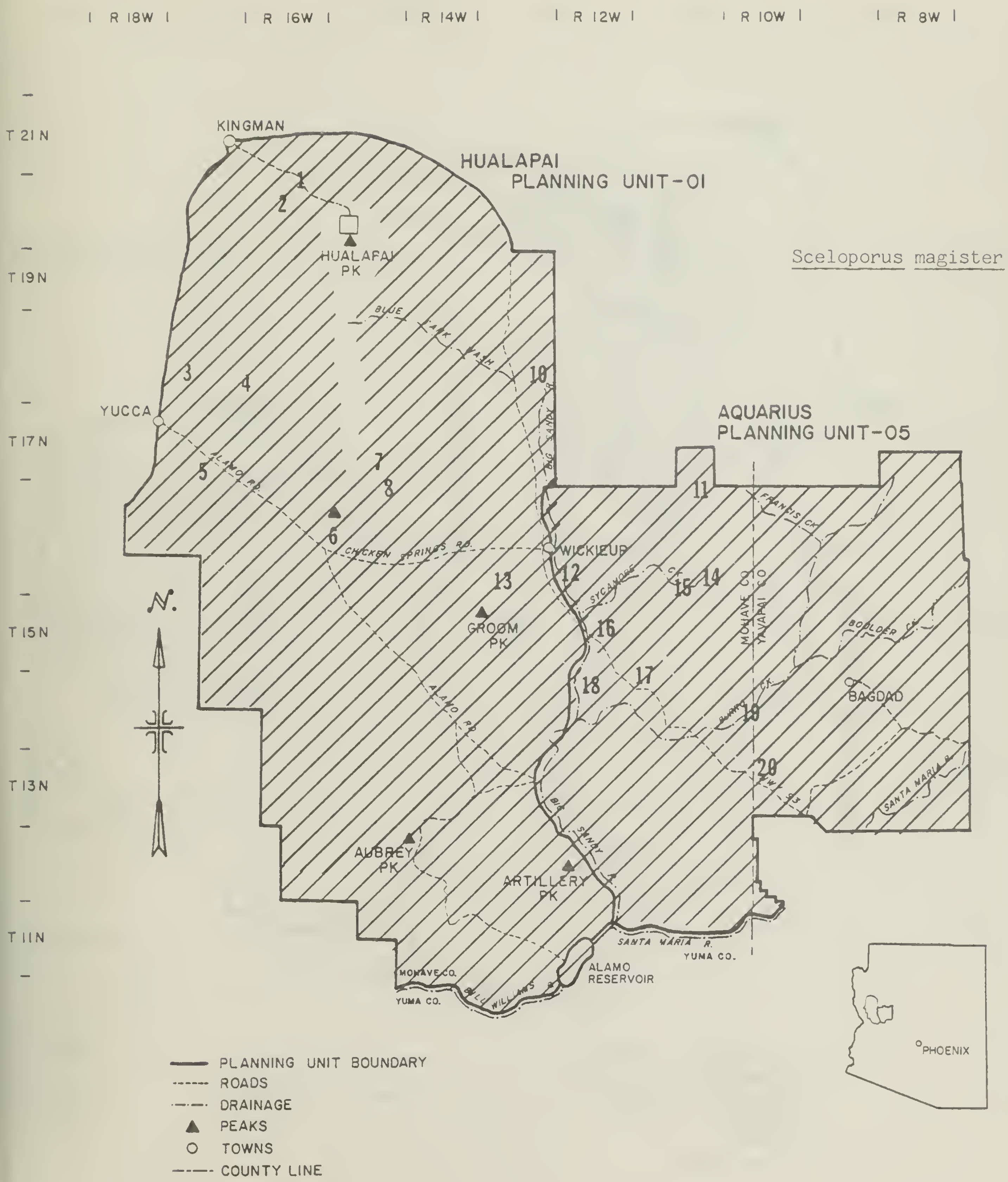
SANTA MARIA R.
BIG SANDY R.
AUBREY
PK
ARTILLERY
PK
SANTA MARIA R.
YUMA CO.
3
ALAMO
RESERVOIR
MOHAVE CO.
YUMA CO.
BILL WILLIAMS R.
PHOENIX
PLANNING UNIT BOUNDARY
ROADS
DRAINAGE
PEAKS
TOWNS
COUNTY LINE
Scale 1"= 8 Miles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KINGMAN
HUALAPAI PLANNING UNIT-01
HUALAPAI PK
Sceloporus magister
BLUE TANK WASH
YUCCA
ALAMO RD.
AQUARIUS PLANNING UNIT-05
BIG SANDY R.
FRANCIS CK.
CHICKEN SPRINGS RD.
WICKIEUP
SYCAMORE CK.
MOHAVE CO.
YAVAPAI CO.
GROOM PK
BOULDER CK.
BAGDAD
BURRO CK.
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SANTA MARIA R.
AUBREY PK
ARTILLERY PK
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MOHAVE CO.
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BILL WILLIAMS R.
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PLANNING UNIT BOUNDARY
ROADS
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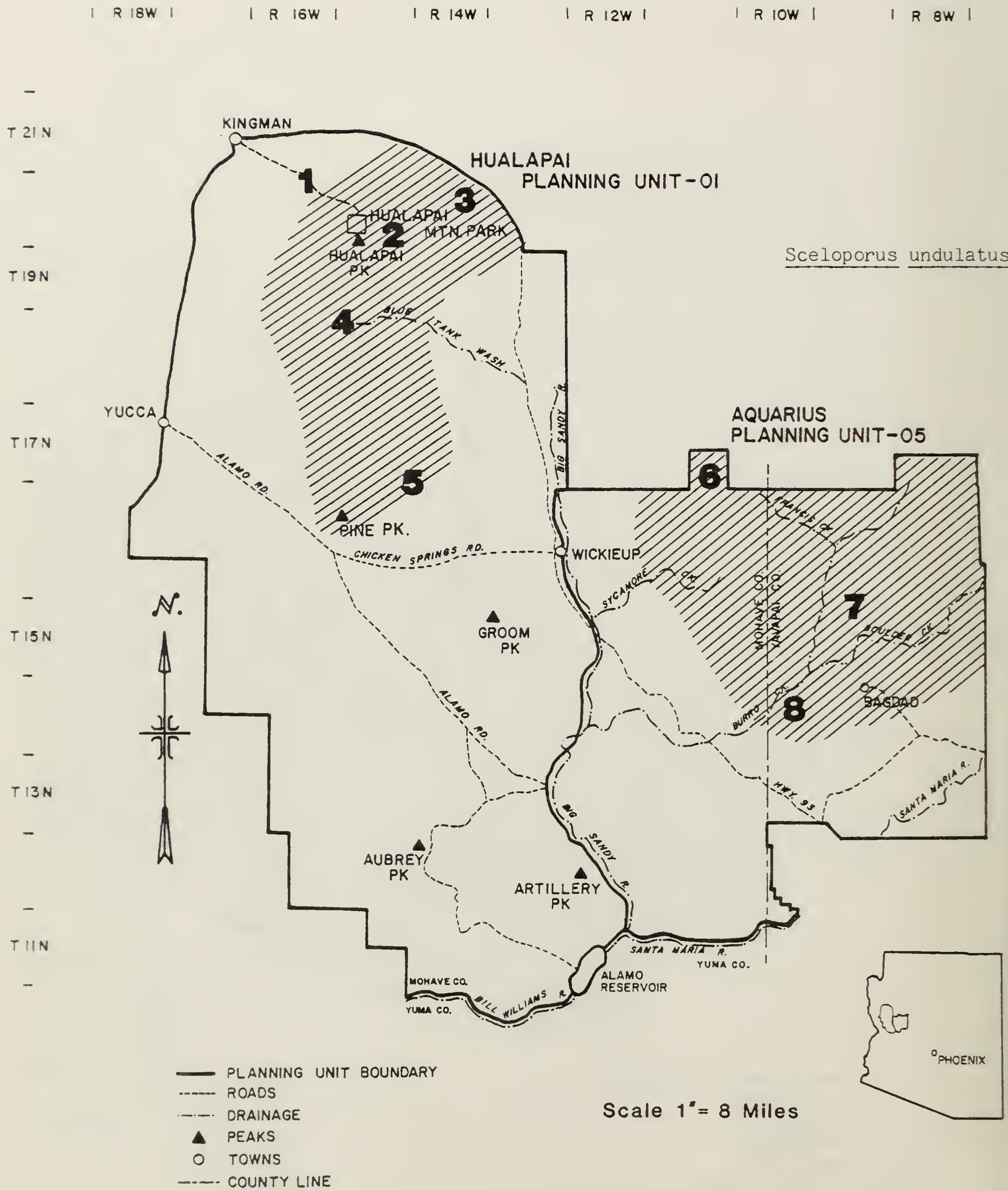
PEAKS
TOWNS
COUNTY LINE



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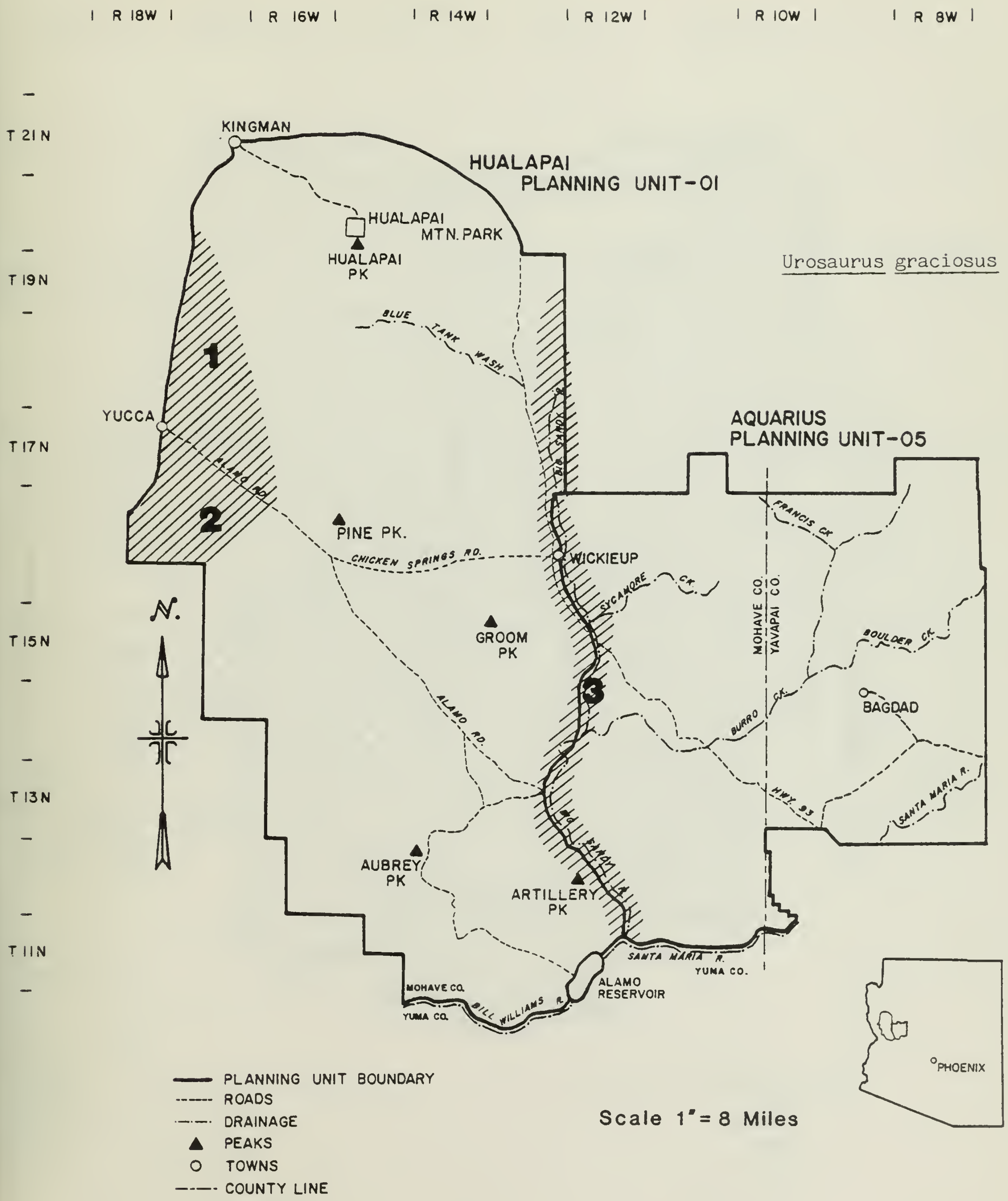
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HUALAPAI
MTN. PARK
HUALAPAI
PK
Urosaurus graciosus
BLUE TANK WASH
1
YUCCA
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CHICKEN SPRINGS RD.
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BIG SANDY R.
AQUARIUS
PLANNING UNIT-05
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SYCAMORE CK.
MOHAVE CO.
YAVAPAI CO.
BOULDER CK.
GROOM
PK
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BURRO CK.
BAGDAD
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AUBREY
PK
ARTILLERY
PK
SANTA MARIA R.
YUMA CO.
ALAMO
RESERVOIR
MOHAVE CO.
YUMA CO.
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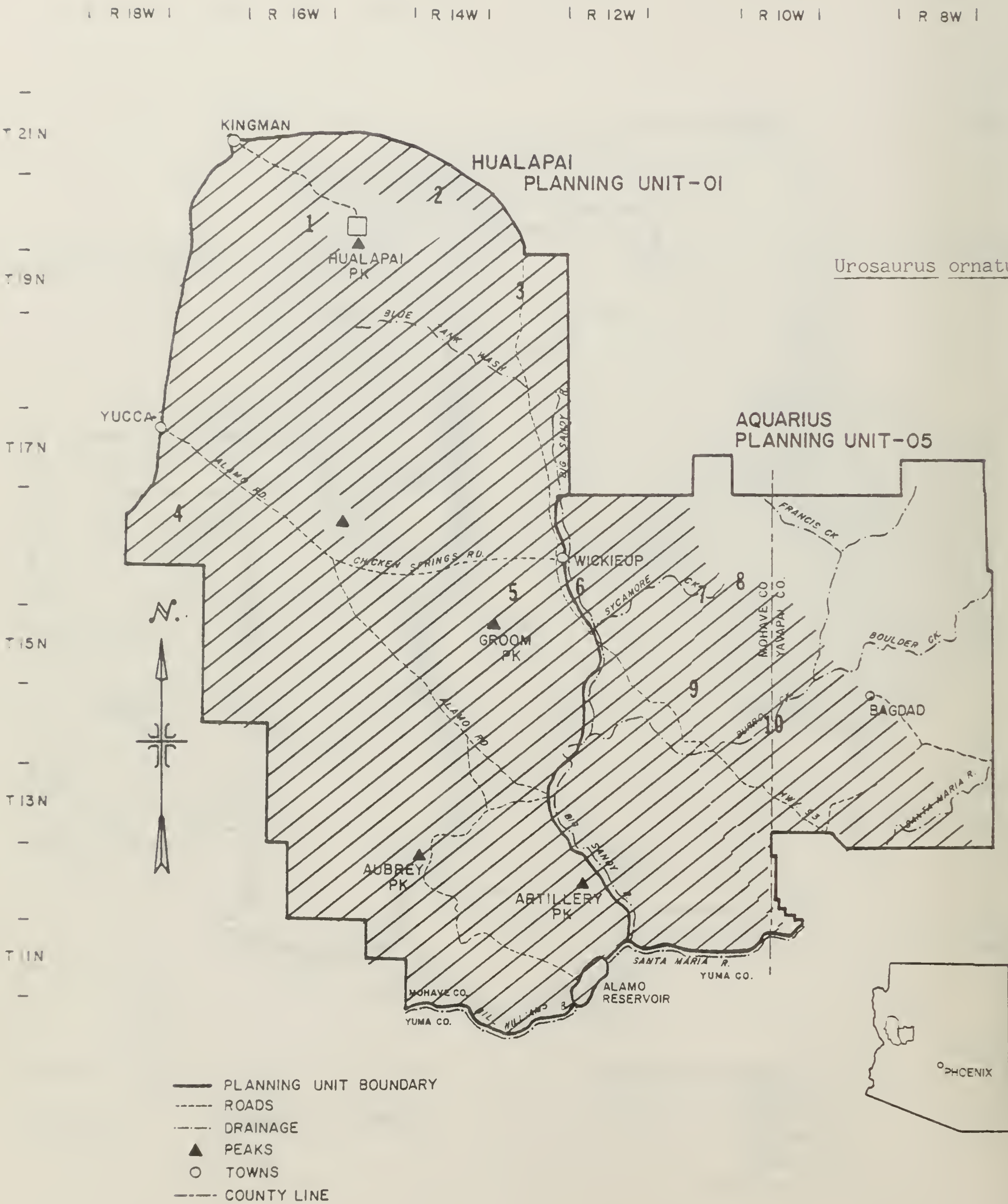
PLANNING UNIT BOUNDARY
ROADS
DRAINAGE
PEAKS
TOWNS
COUNTY LINE
Scale 1" = 8 Miles



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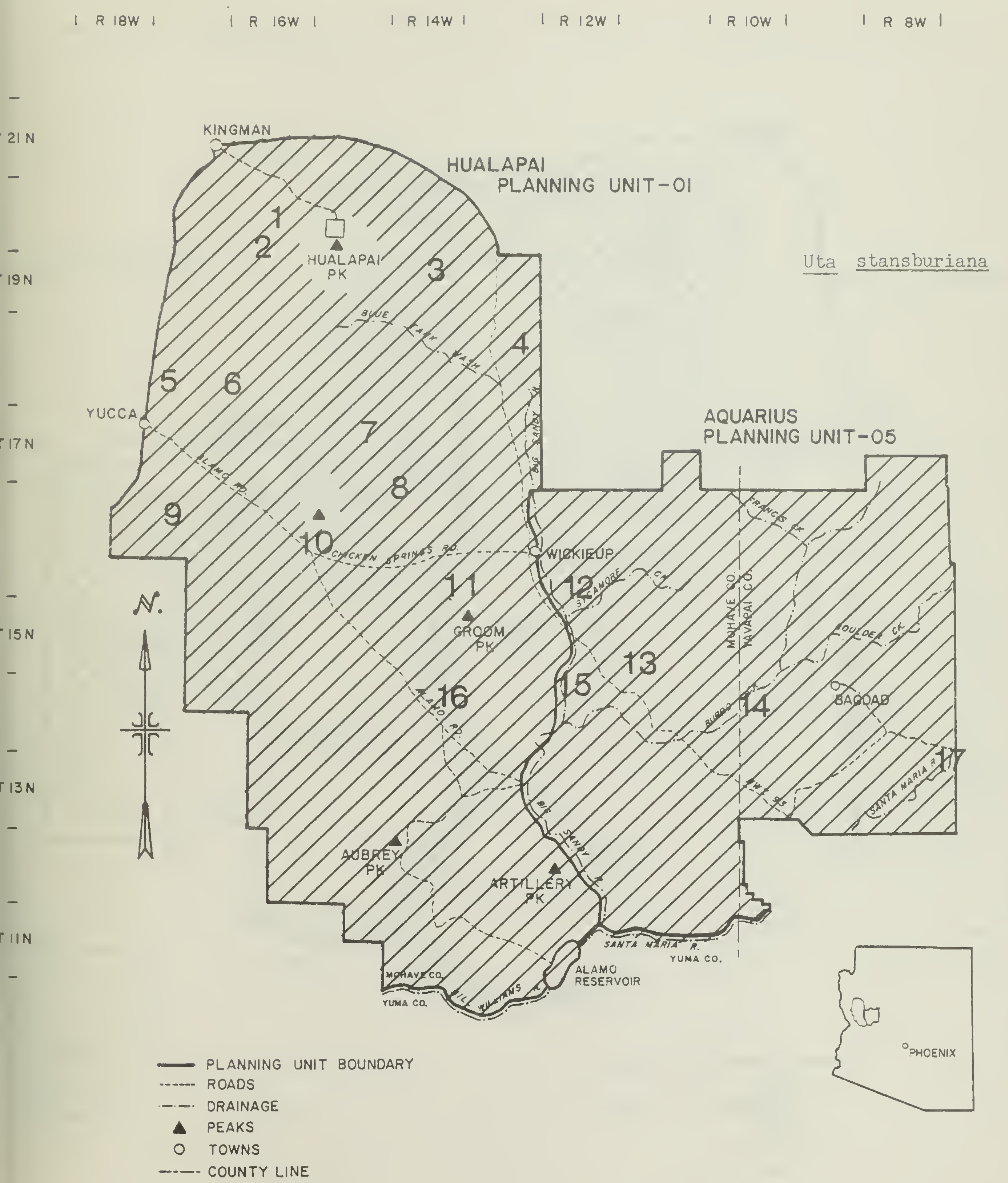
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HUALAPAI PK
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ALAMO RD.
AQUARIUS
PLANNING UNIT-05
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WICKIEUP
SYCAMORE CK.
FRANCIS CK.
MOHAVE CO.
YAVAPAI CO.
BOULDER CK.
GROOM PK
BAGDAD
BURRO CK.
SANTA MARIA R.
AUBREY PK
ARTILLERY PK
BIG SANDY R.
SANTA MARIA R.
YUMA CO.
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YUMA CO.
BILL WILLIAMS R.
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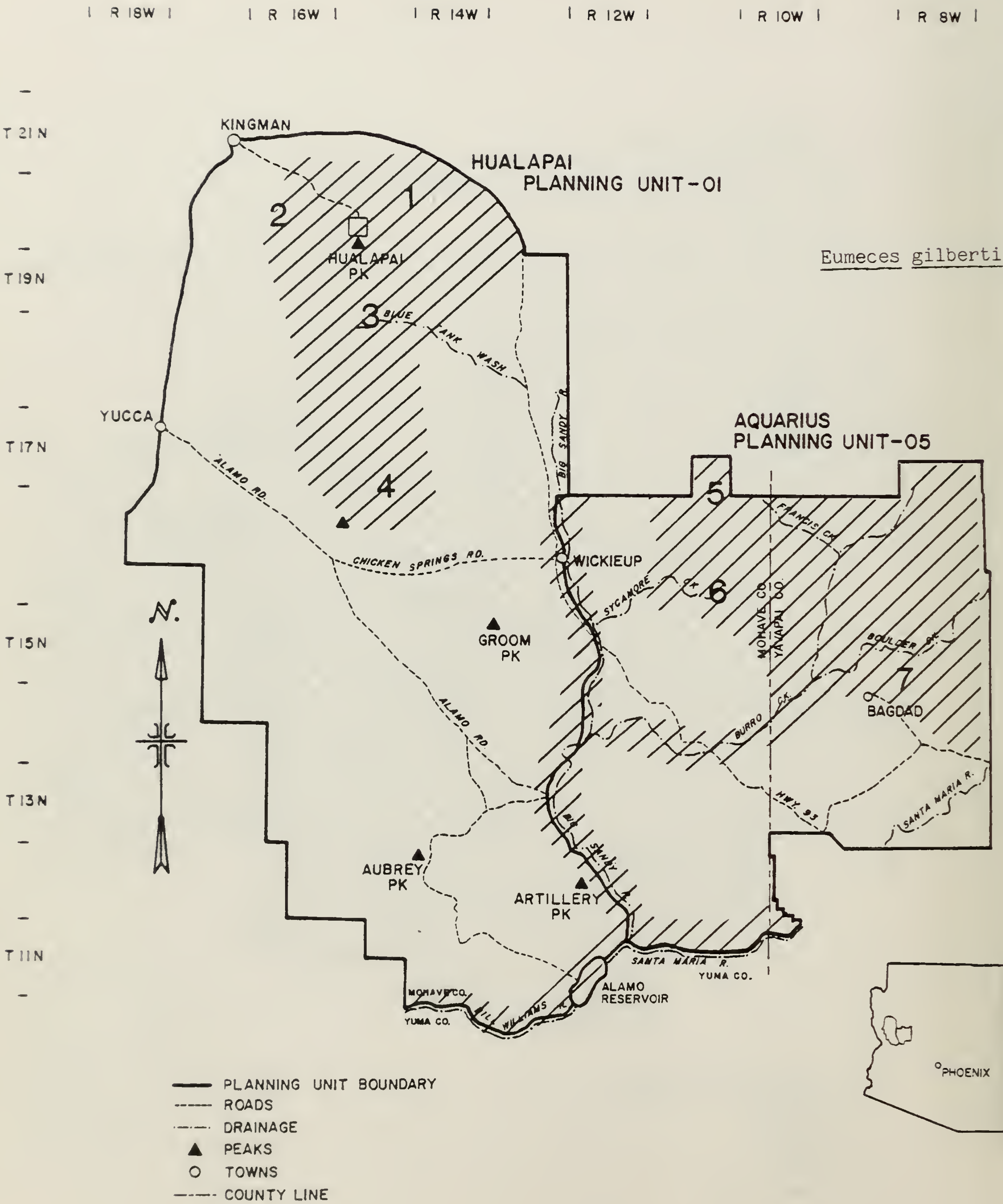
PLANNING UNIT BOUNDARY
ROADS
DRAINAGE
PEAKS
TOWNS
COUNTY LINE



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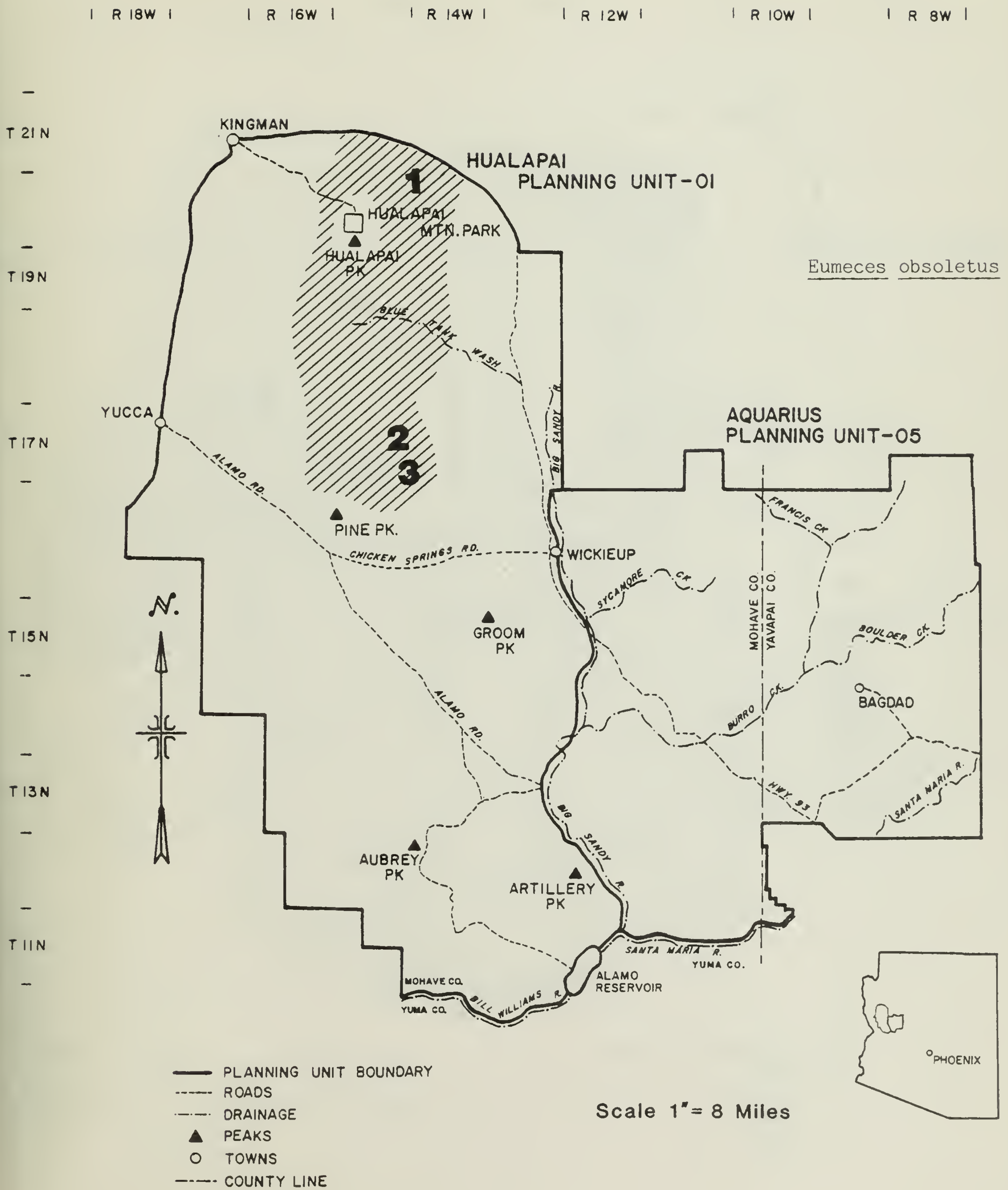
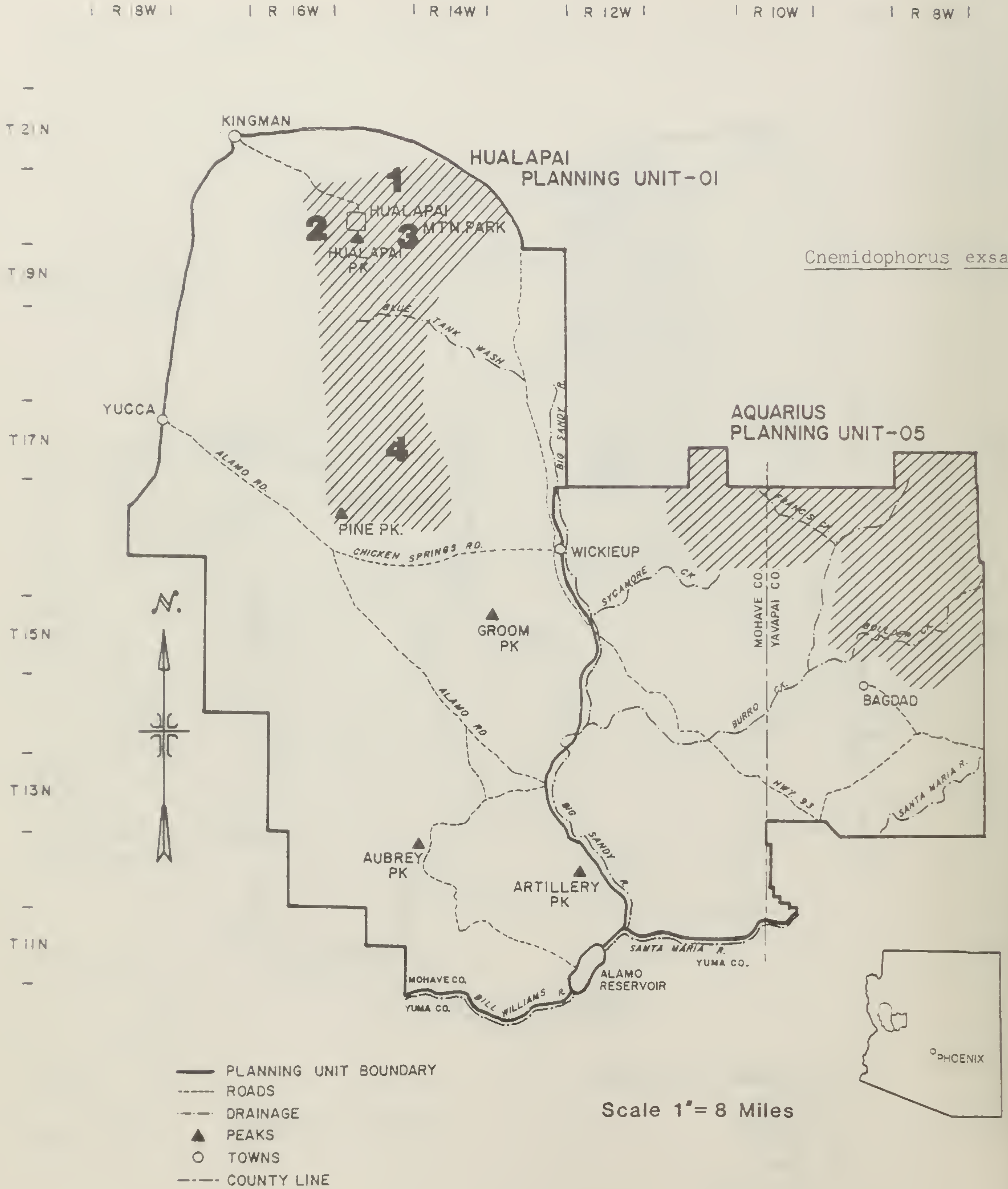
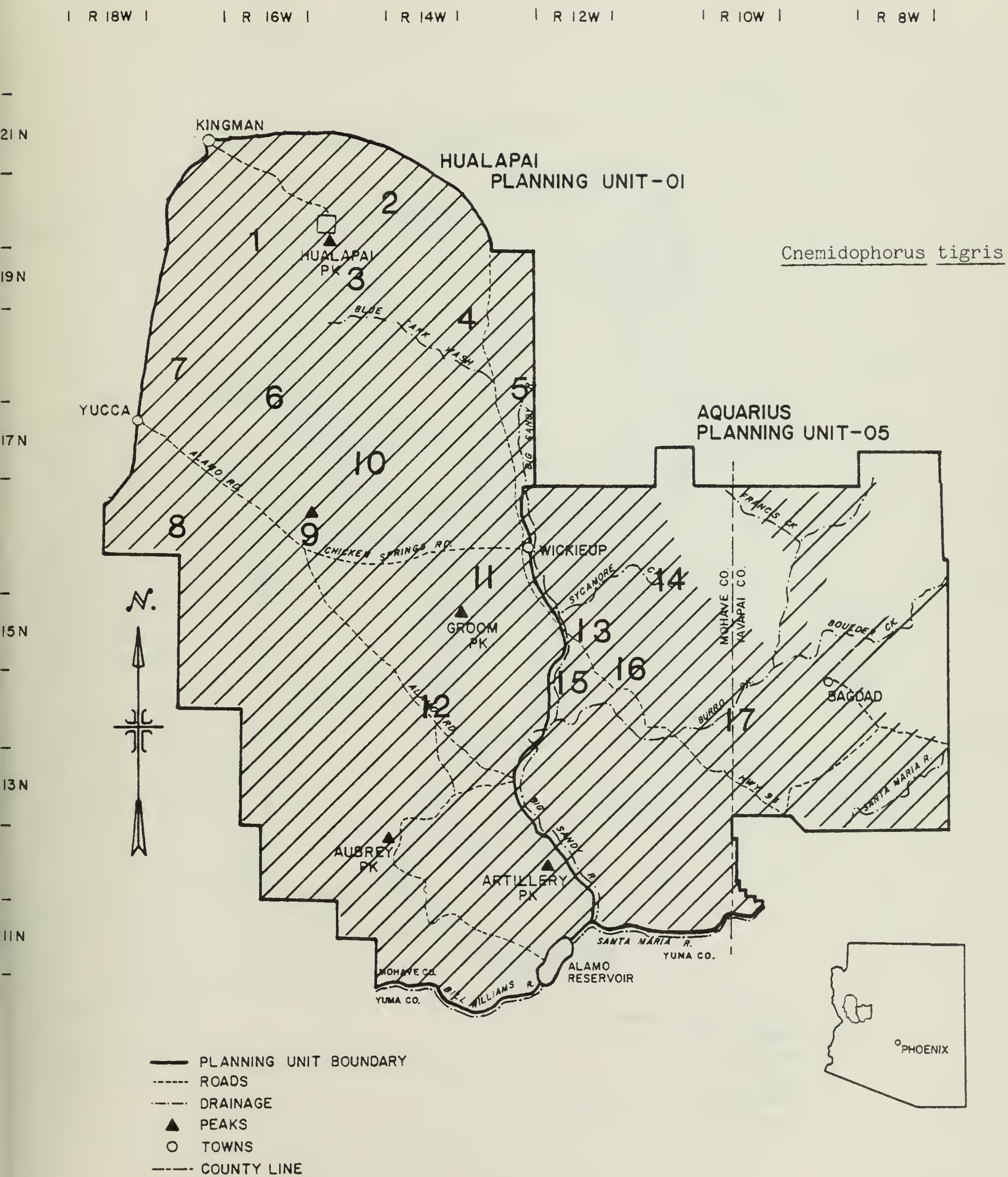
Eumeces obsoletus





Cnemidophorus exsangu

Cnemidophorus tigris



APPENDIX 3 (CONT'D)

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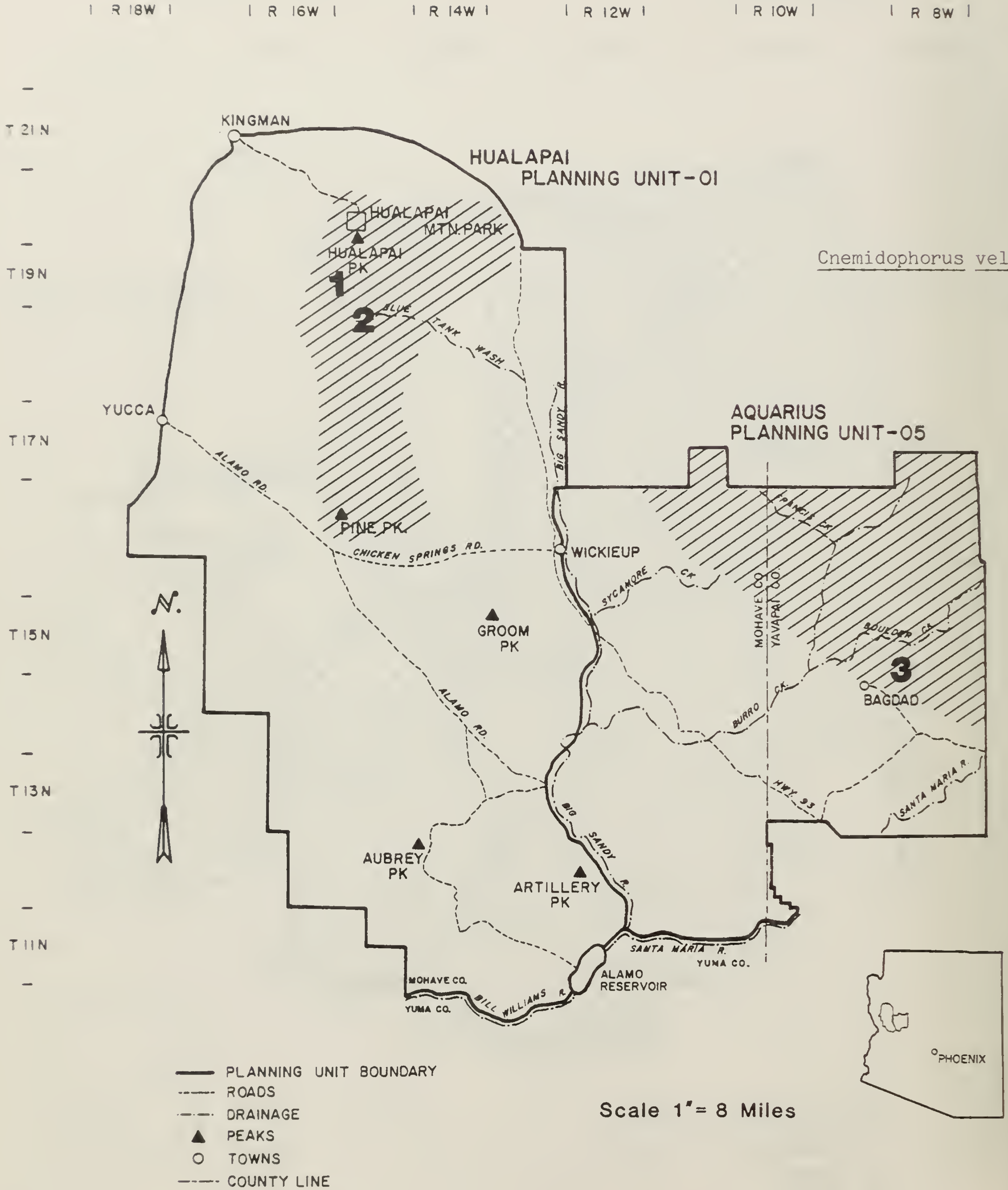

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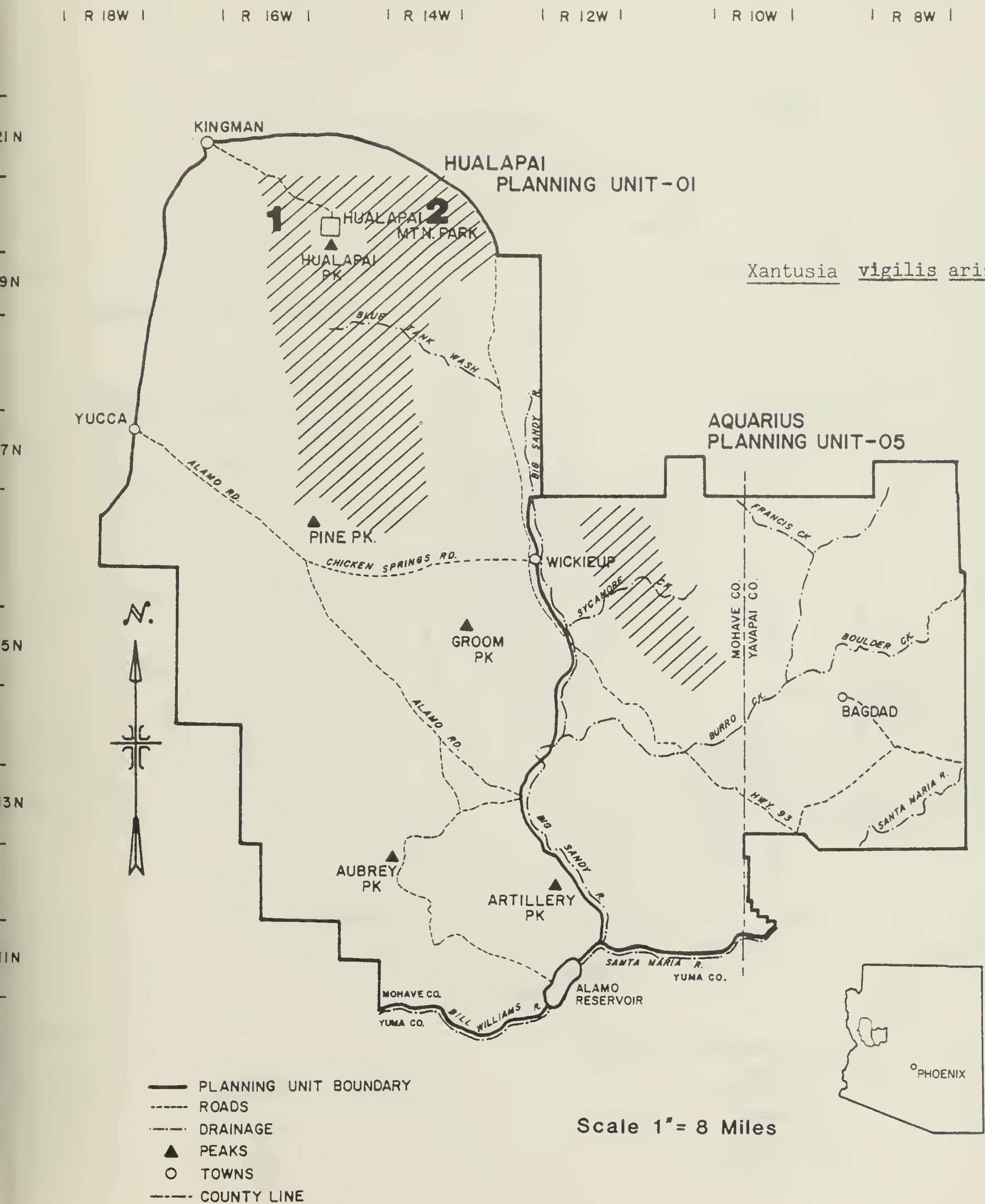

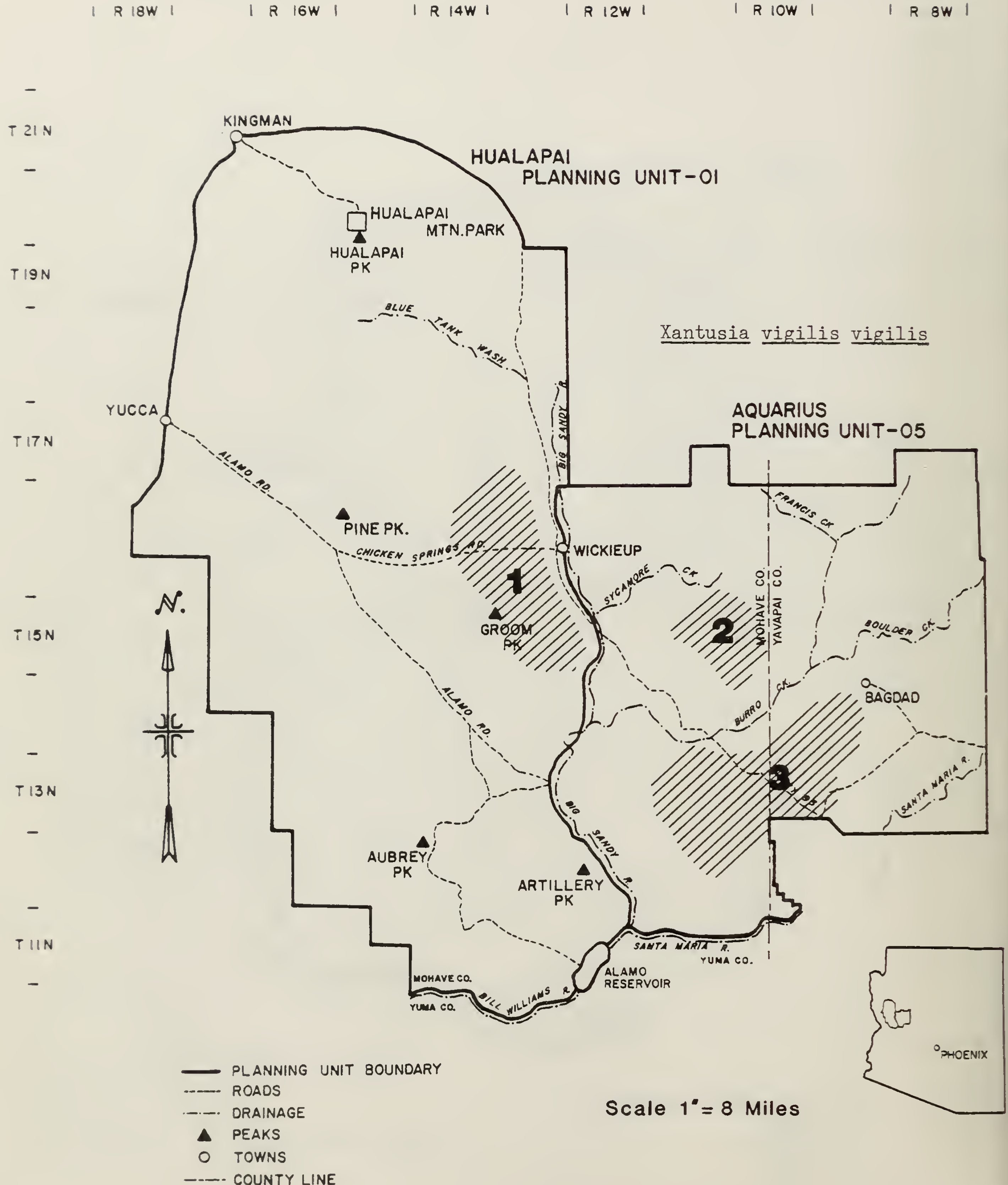
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KINGMAN
HUALAPAI PLANNING UNIT-01
HUALAPAI MTN. PARK
HUALAPAI PK
BLUE TANK WASH
Xantusia vigilis vigilis
YUCCA
AQUARIUS PLANNING UNIT-05
BIG SANDY R.
ALAMO RD.
PINE PK.
CHICKEN SPRINGS RD.
WICKIEUP
FRANCIS CK
SYCAMORE CK
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GROOM PK
MOHAVE CO.
YAVAPAI CO.
BOULDER CK
BAGDAD
BURRO CK
SANTA MARIA R.
AUBREY PK
ARTILLERY PK
SANTA MARIA R.
YUMA CO.
ALAMO RESERVOIR
MOHAVE CO.
YUMA CO.
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PLANNING UNIT BOUNDARY
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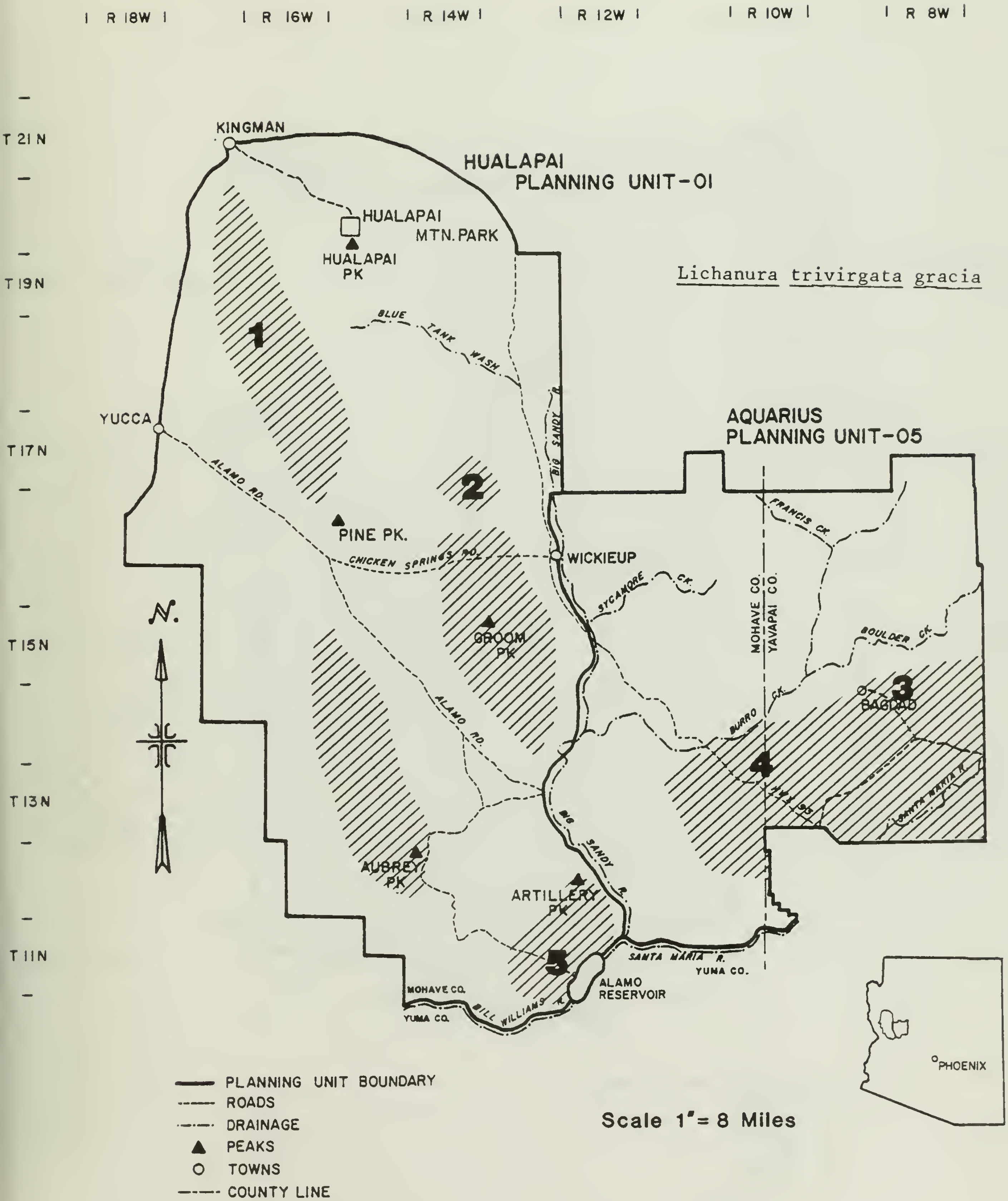
Scale 1" = 8 Miles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PLANNING UNIT-01
HUALAPAI
MTN. PARK
HUALAPAI
PK
Lichanura trivirgata gracia
BLUE TANK WASH
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YUCCA
BIG SANDY R.
AQUARIUS
PLANNING UNIT-05
ALAMO RD.
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PINE PK.
FRANCIS CK.
CHICKEN SPRINGS RD.
WICKIEUP
SYCAMORE CK.
MOHAVE CO.
YAVAPAI CO.
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PK
BOULDER CK.
ALAMO RD.
BURRO CK.
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BAGDAD
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HWY 93
SANTA MARIA R.
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AUBREY
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YUMA CO.
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BILL WILLIAMS R.
YUMA CO.
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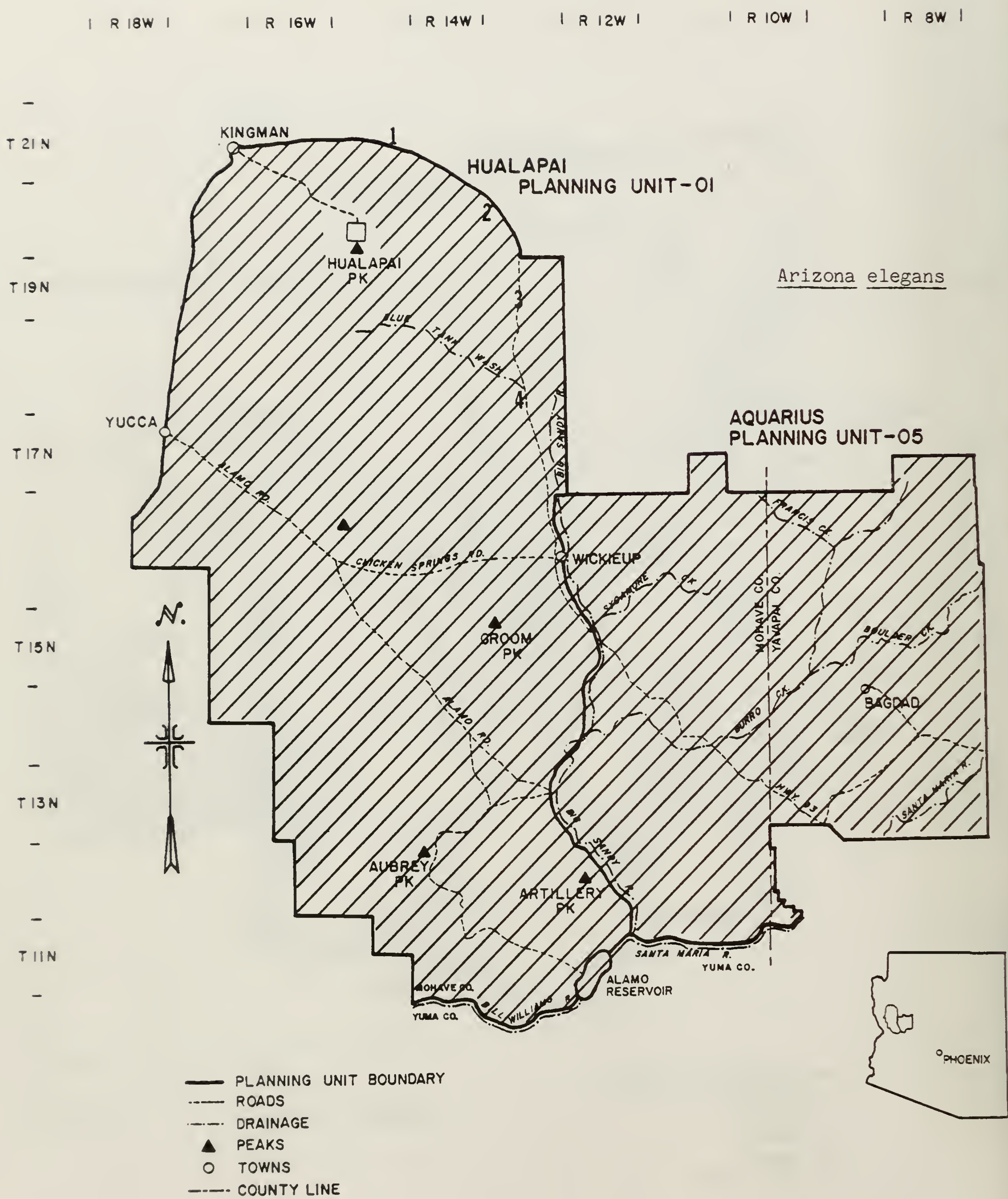
Scale 1" = 8 Miles



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PK
Arizona elegans
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WASH
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PLANNING UNIT-05
ALAMO RD.
CHICKEN SPRINGS RD.
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MOHAVE CO.
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GROOM
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BOULDER CK.
BAGDAD
BURRO CK.
ALAMO RD.
HWY. 93
SANTA MARIA R.
BIG SANDY
AUBREY
PK
ARTILLERY
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SANTA MARIA R.
YUMA CO.
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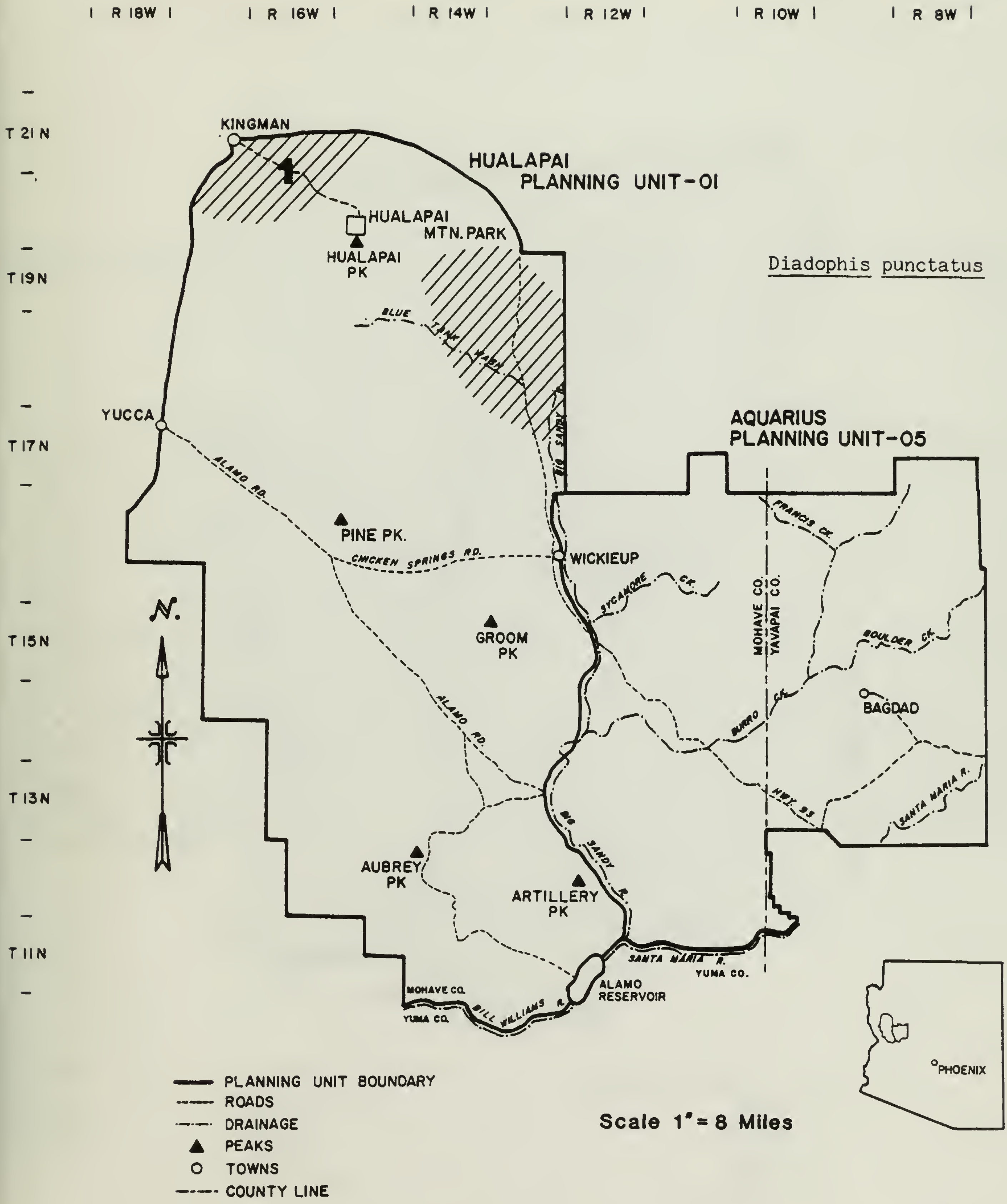
COUNTY LINE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PLANNING UNIT-01
HUALAPAI
MTN. PARK
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PK
Diadophis punctatus
BLUE TANK WASH
YUCCA
BIG SANDY R.
AQUARIUS
PLANNING UNIT-05
ALAMO RD.
FRANCIS CK.
PINE PK.
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BURRO CK.
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SANTA MARIA R.
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AUBREY
PK
ARTILLERY
PK
SANTA MARIA R.
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RESERVOIR
MOHAVE CO.
YUMA CO.
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ROADS
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TOWNS
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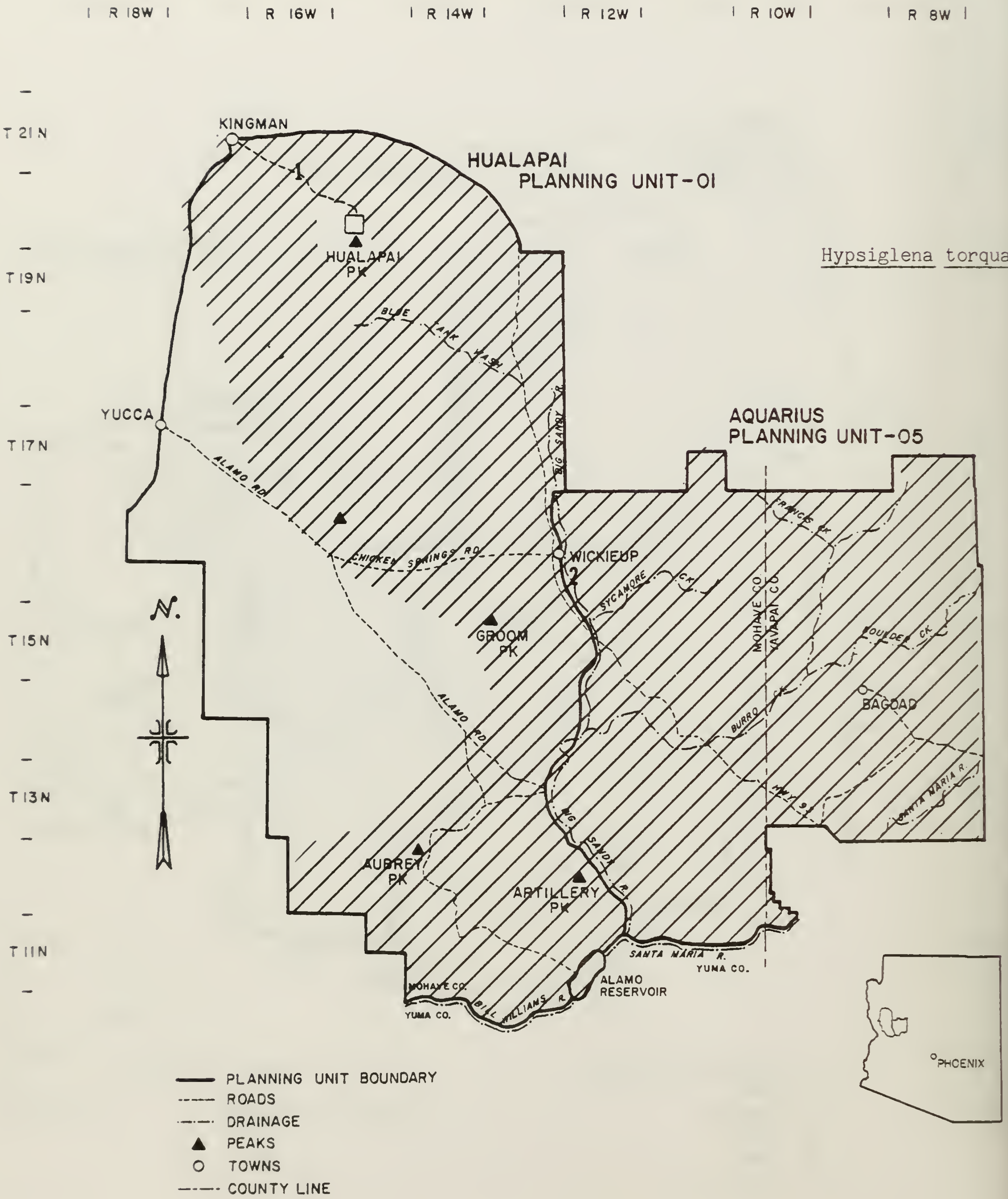
Scale 1" = 8 Miles



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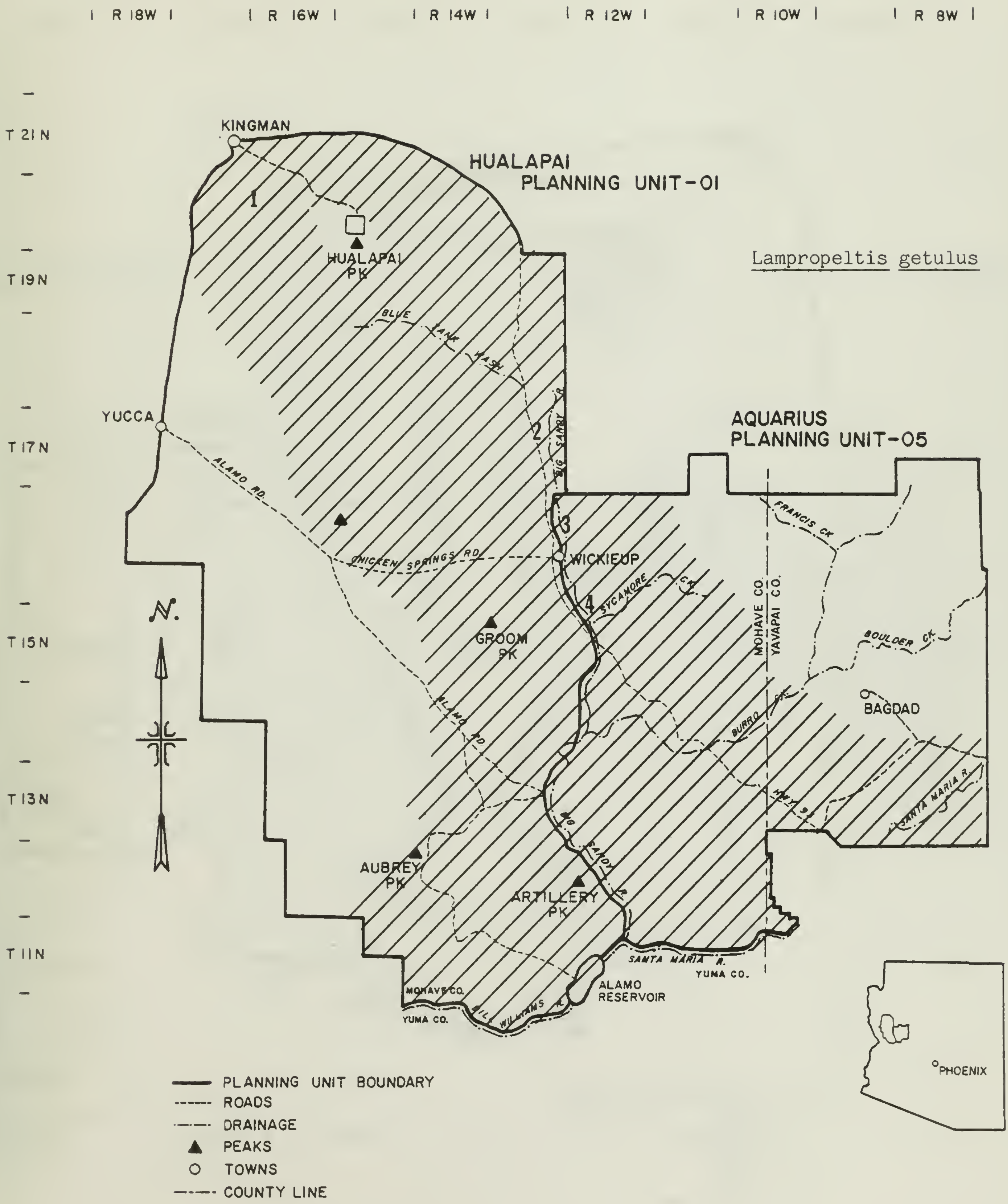
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Lampropeltis getulus
BLUE TANK WASH
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PLANNING UNIT-05
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CHICKEN SPRINGS RD.
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SYCAMORE CK.
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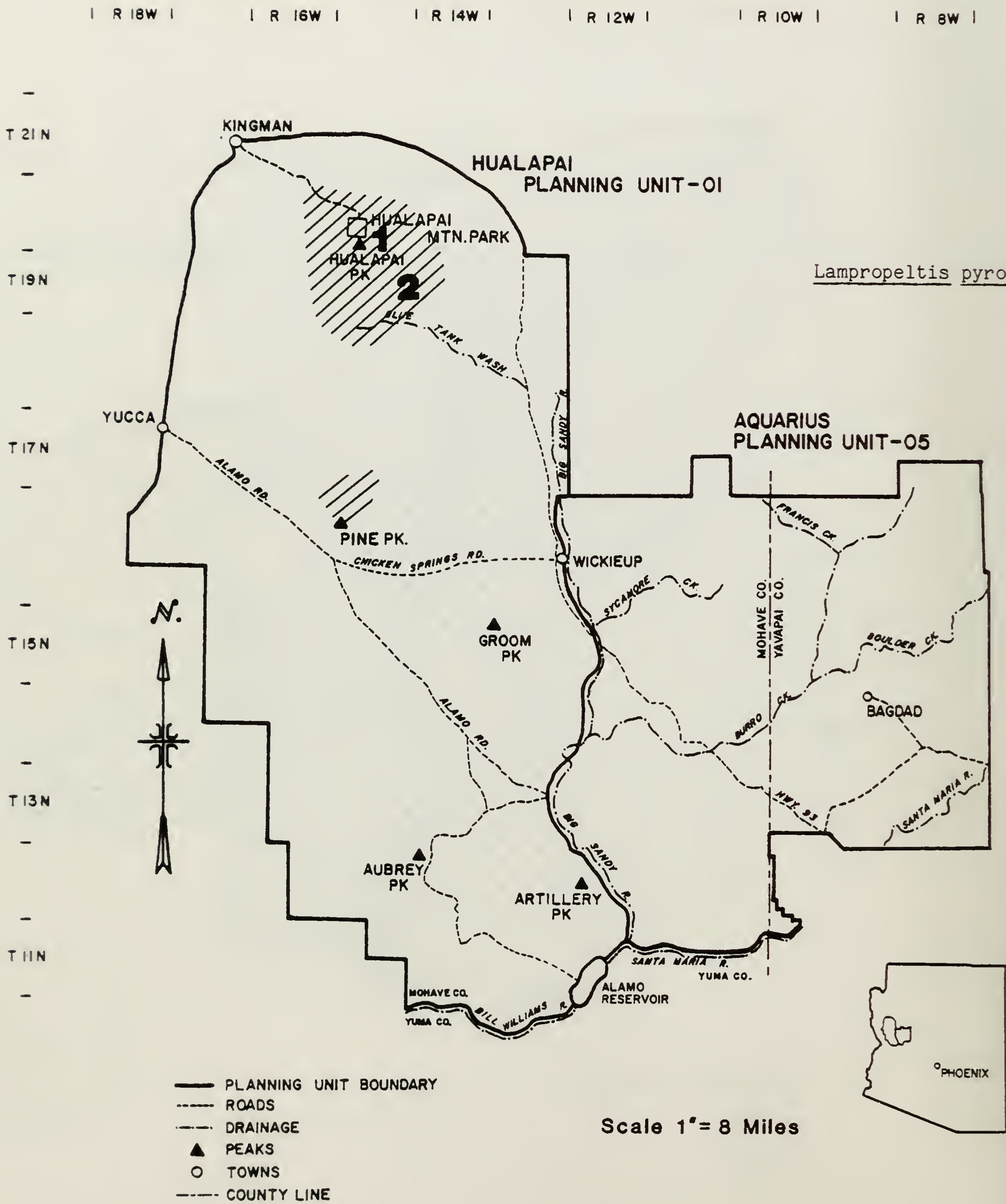
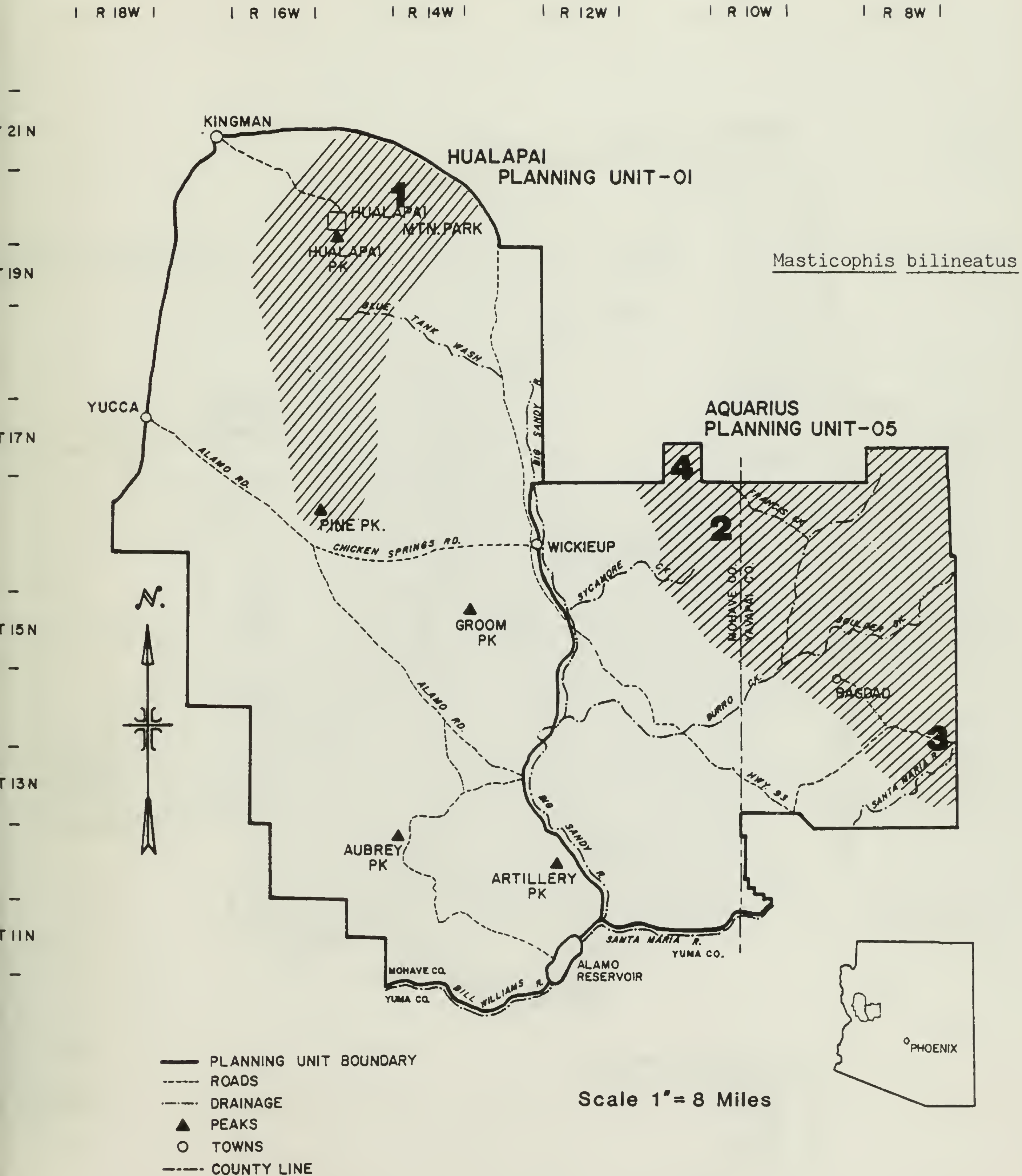


Lampropeltis pyromel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Masticophis bilineatus
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YUCCA
ALAMO RD.
AQUARIUS
PLANNING UNIT-05
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SYCAMORE
CK.
MOHAVE CO.
YAVAPAI CO.
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BURRO
CK.
BAGDAD
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SANTA MARIA R.
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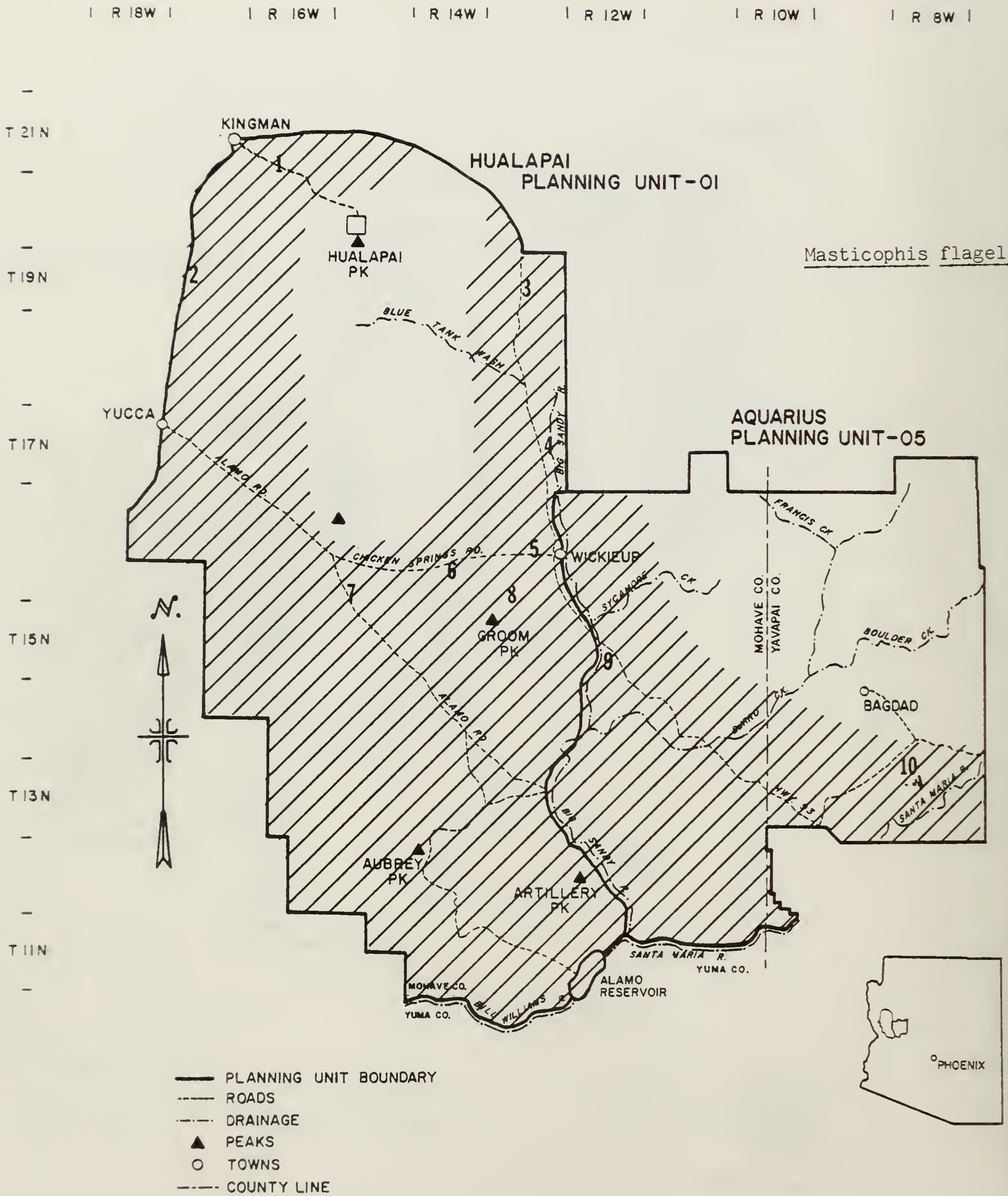
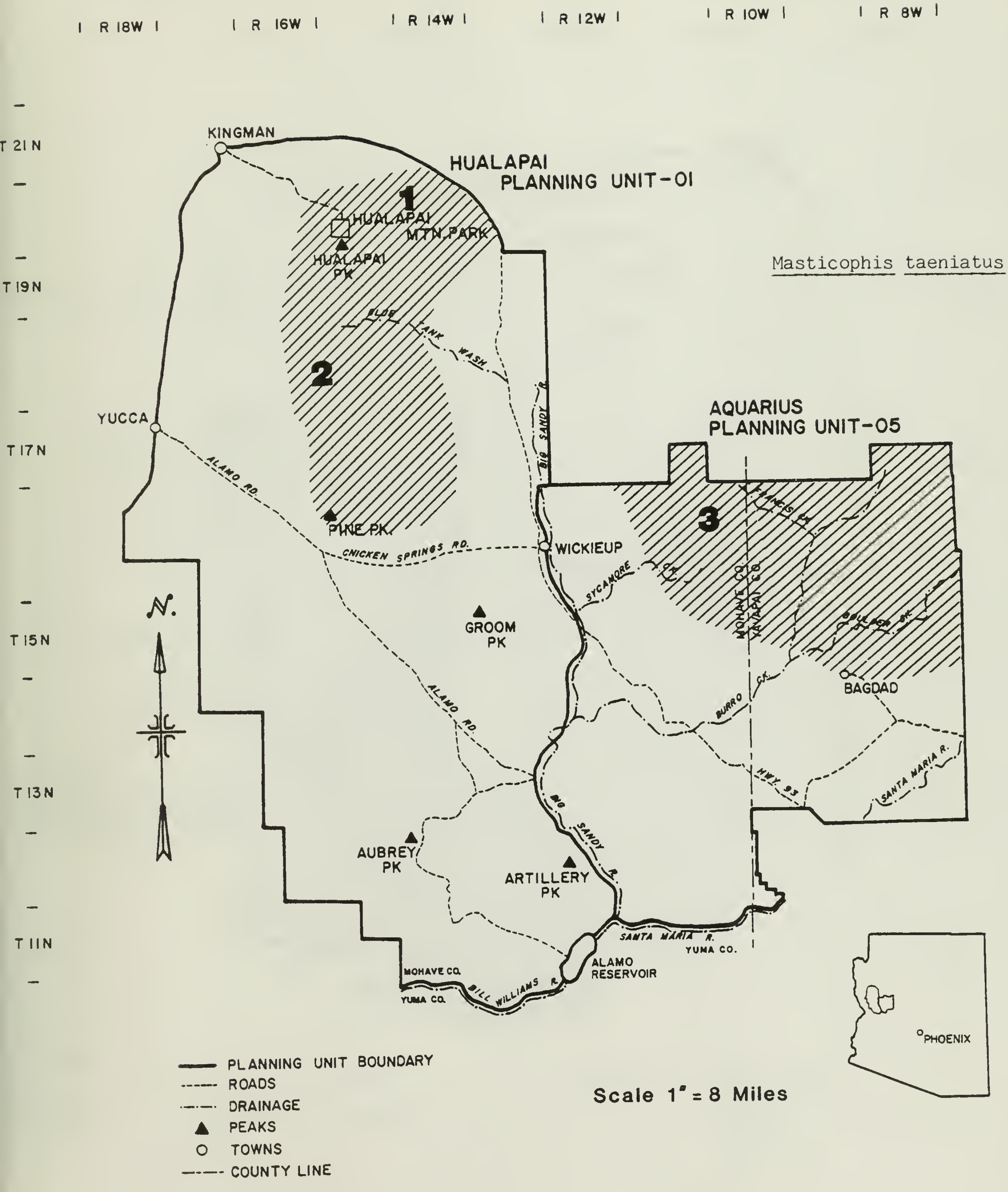
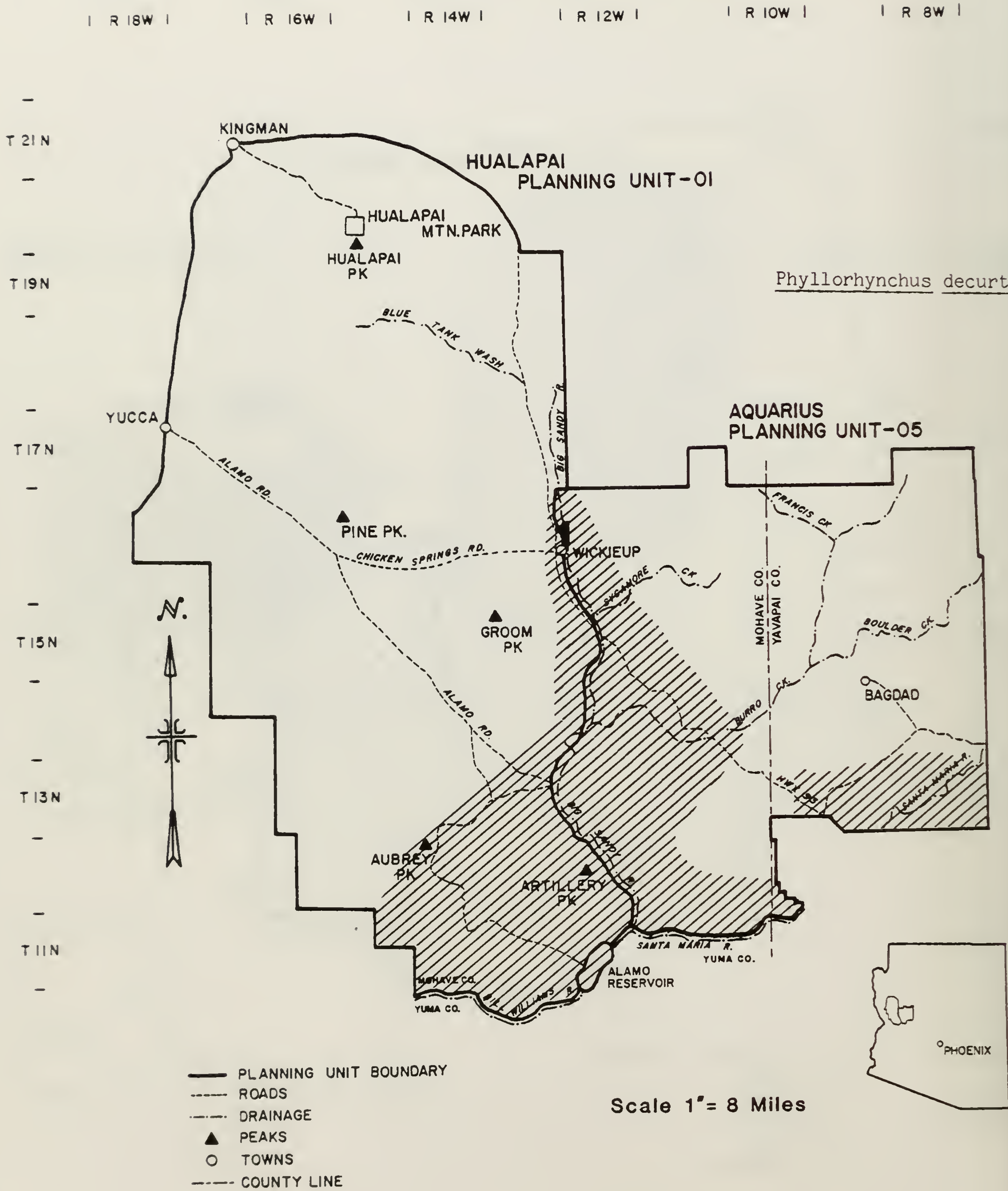
SANDY
R.
AUBREY
PK
ARTILLERY
PK
SANTA MARIA R.
YUMA CO.
ALAMO
RESERVOIR
MOHAVE CO.
YUMA CO.
BILL WILLIAMS R.
PHOENIX
PLANNING UNIT BOUNDARY
ROADS
DRAINAGE
PEAKS
TOWNS
COUNTY LINE
Scale 1" = 8 Miles

Masticophis flagellum



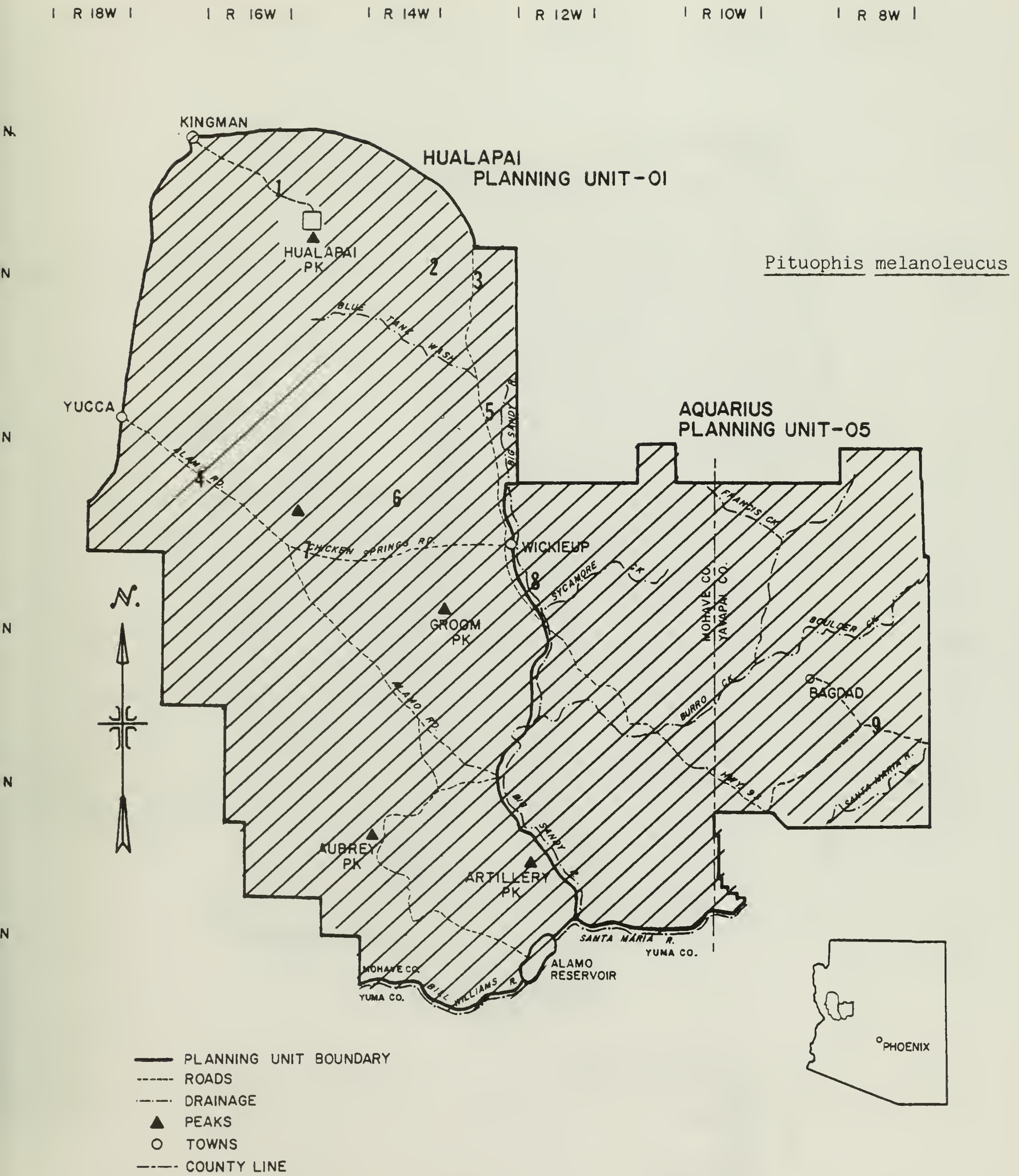


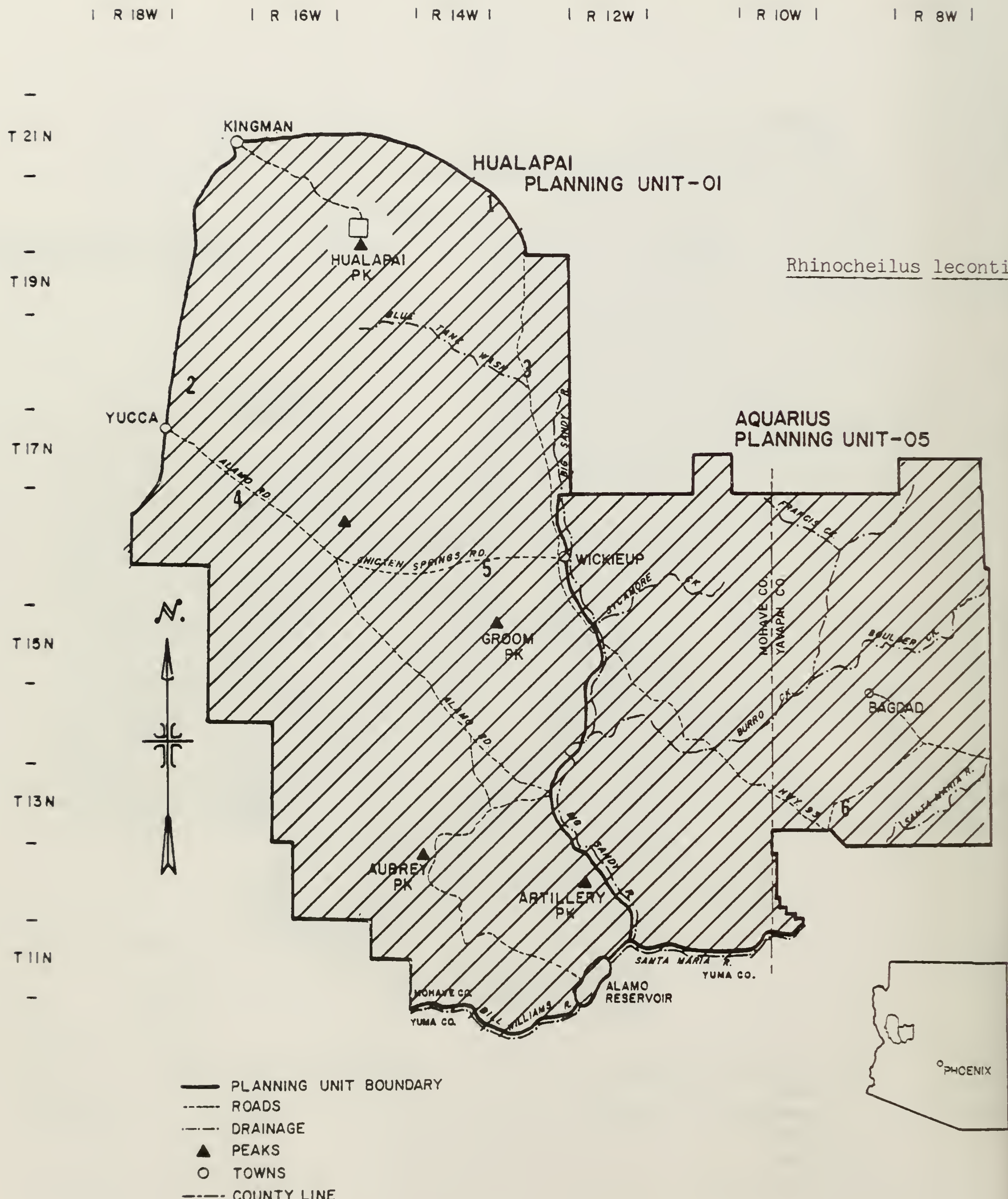
Masticophis taeniatus



Phyllorhynchus decurtatu

Pituophis melanoleucus

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KINGMAN
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HUALAPAI PK
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ALAMO RD.
BIG SANDY R.
AQUARIUS
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FRANCIS CK.
CHICKEN SPRINGS RD.
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SYCAMORE CK.
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MOHAVE CO.
YAVAPAI CO.
BOULDER CK.
BAGDAD
BURRO CK.
ALAMO RD.
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ARTILLERY PK
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MOHAVE CO.
YUMA CO.
BILL WILLIAMS R.
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PLANNING UNIT BOUNDARY
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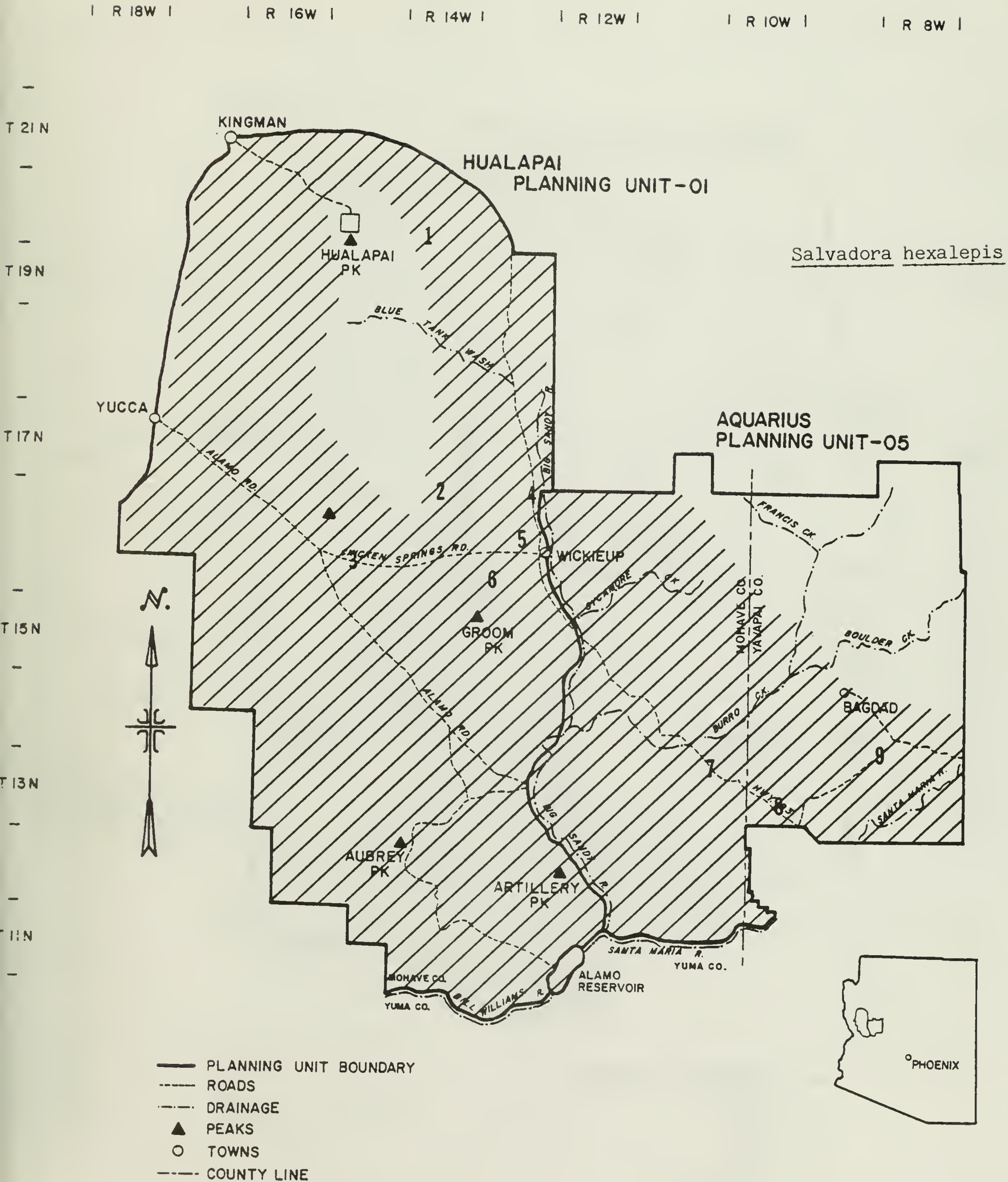
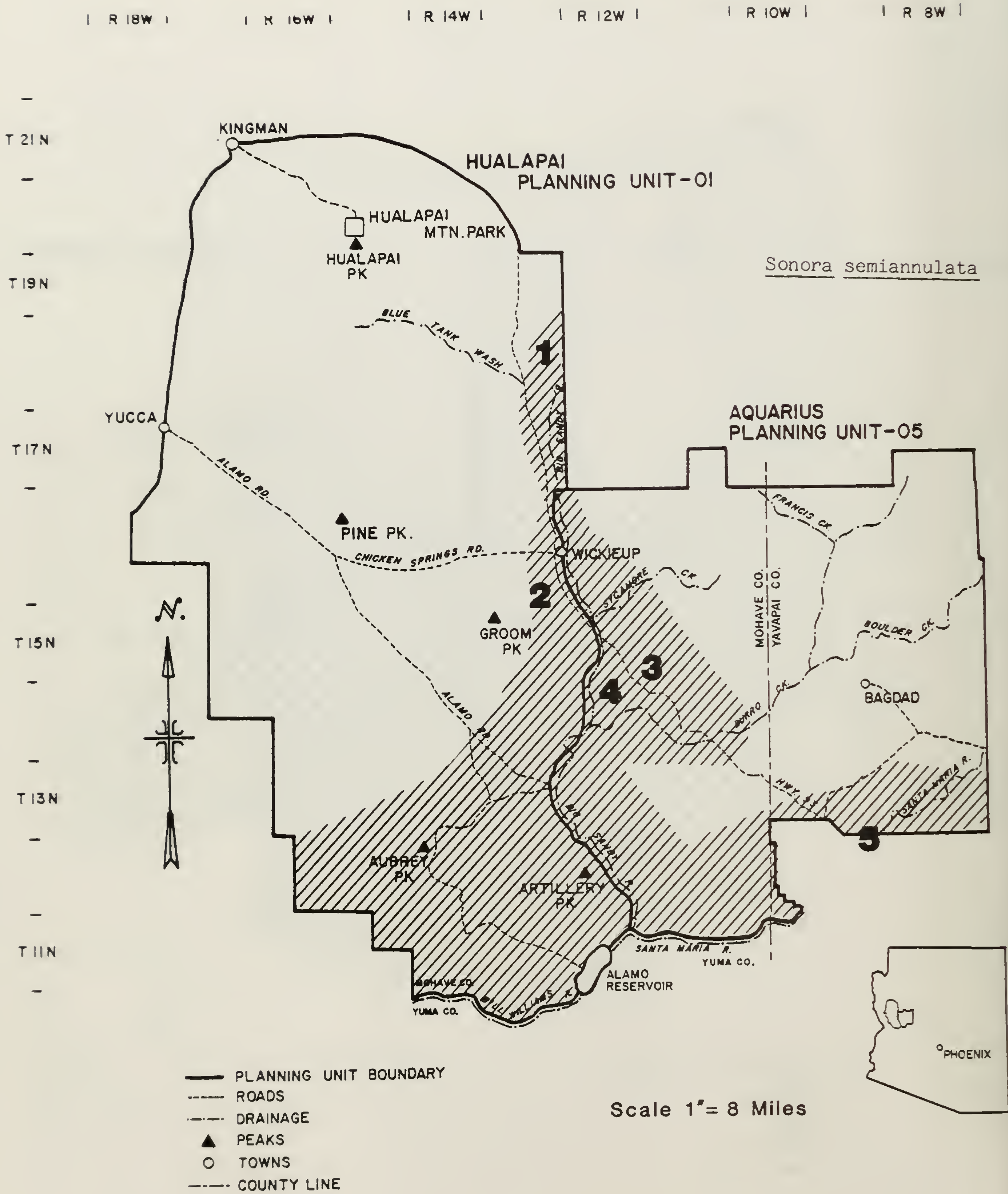
DRAINAGE
PEAKS
TOWNS
COUNTY LINE

APPENDIX 3 (CONT'D)





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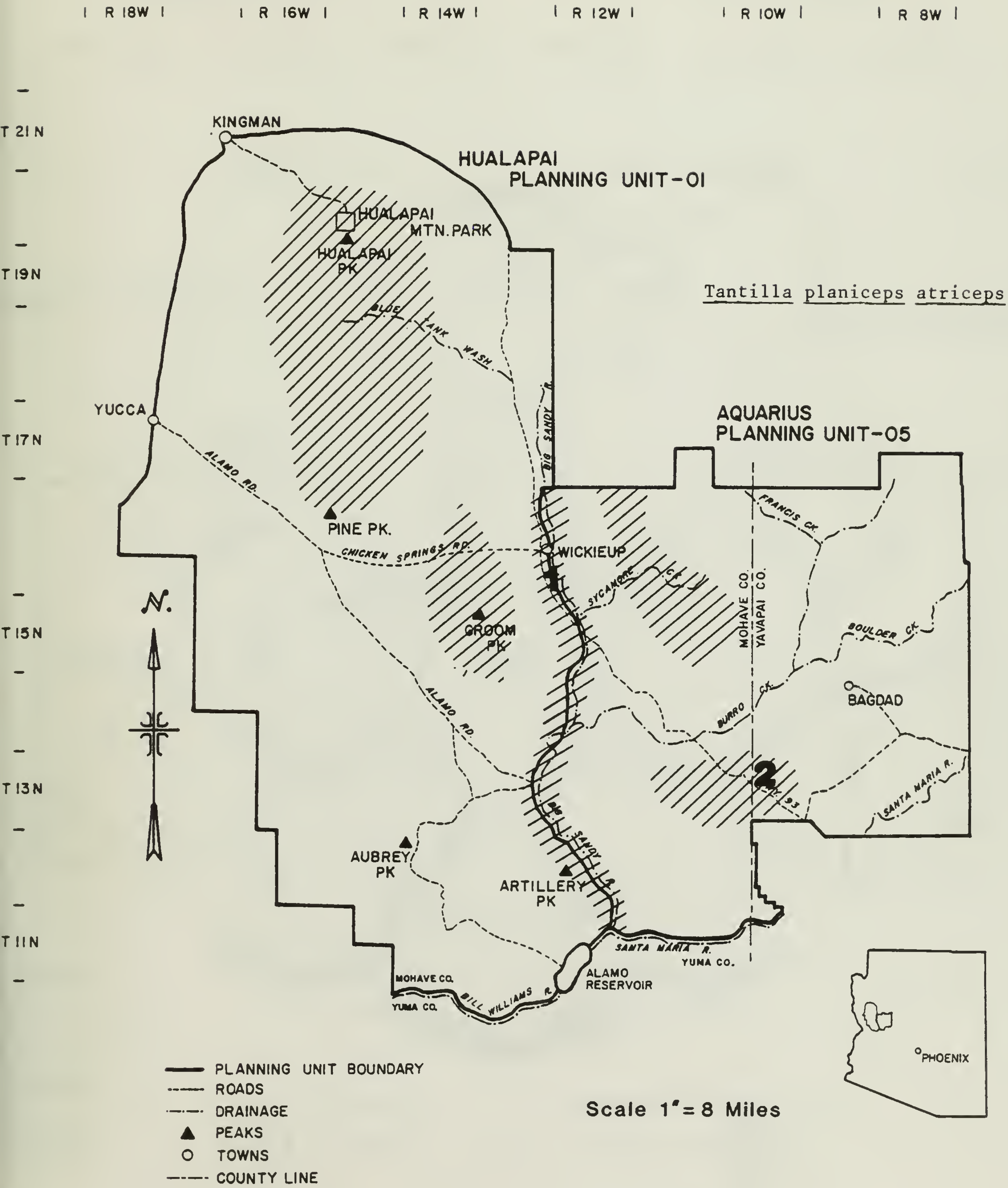
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MTN. PARK
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PK
BLUE TANK WASH
BIG SANDY R.
YUCCA
ALAMO RD.
AQUARIUS
PLANNING UNIT-05
Tantilla planiceps atriceps
FRANCIS CK.
PINE PK.
CHICKEN SPRINGS RD.
WICKIEUP
SYCAMORE CK.
MOHAVE CO.
YAVAPAI CO.
N.
GROOM
PK
BOULDER CK.
BAGDAD
BURRO CK.
ALAMO RD.
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AUBREY
PK
ARTILLERY
PK
SANTA MARIA R.
YUMA CO.
ALAMO
RESERVOIR
MOHAVE CO.
YUMA CO.
BILL WILLIAMS R.
PHOENIX
PLANNING UNIT BOUNDARY
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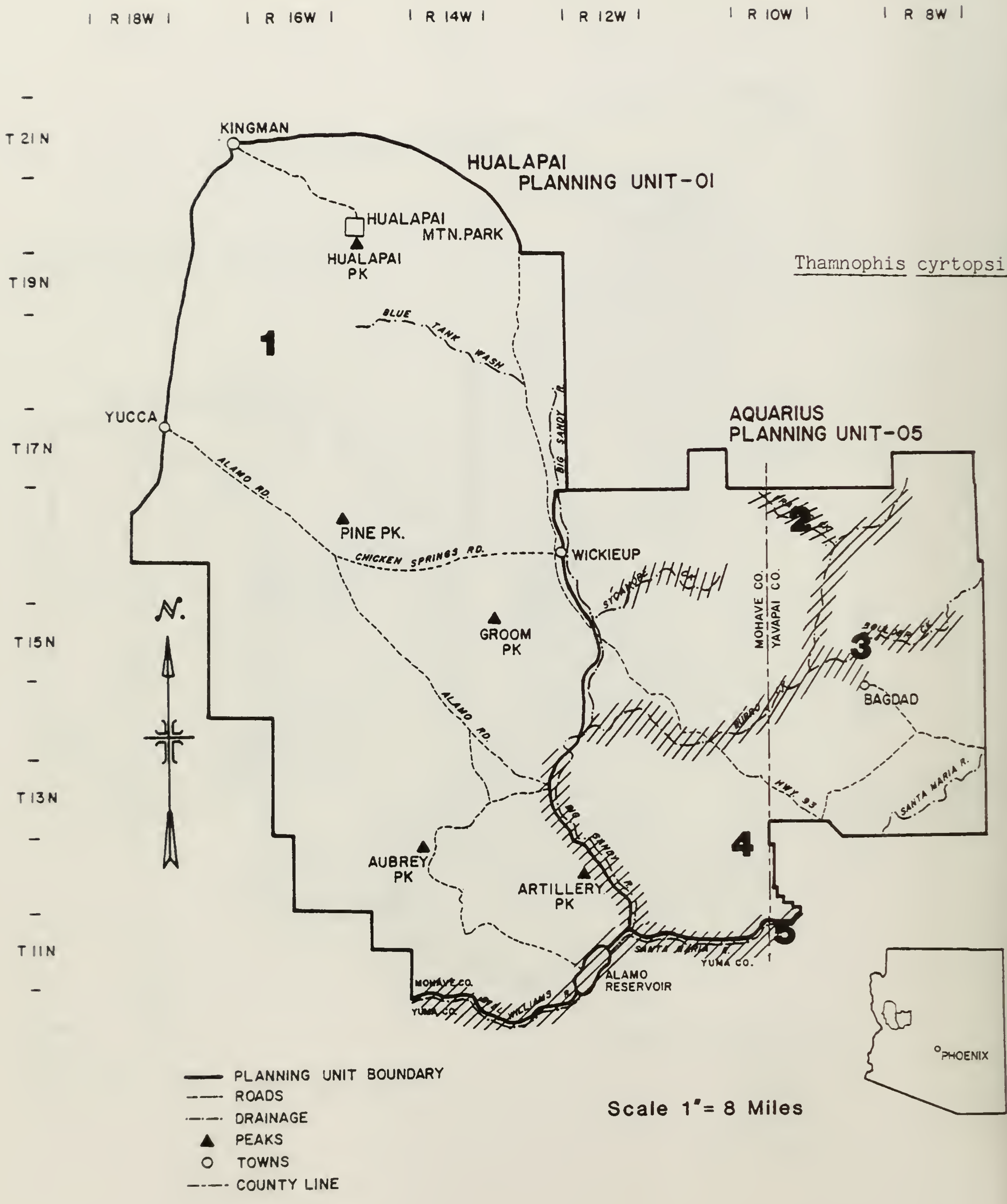
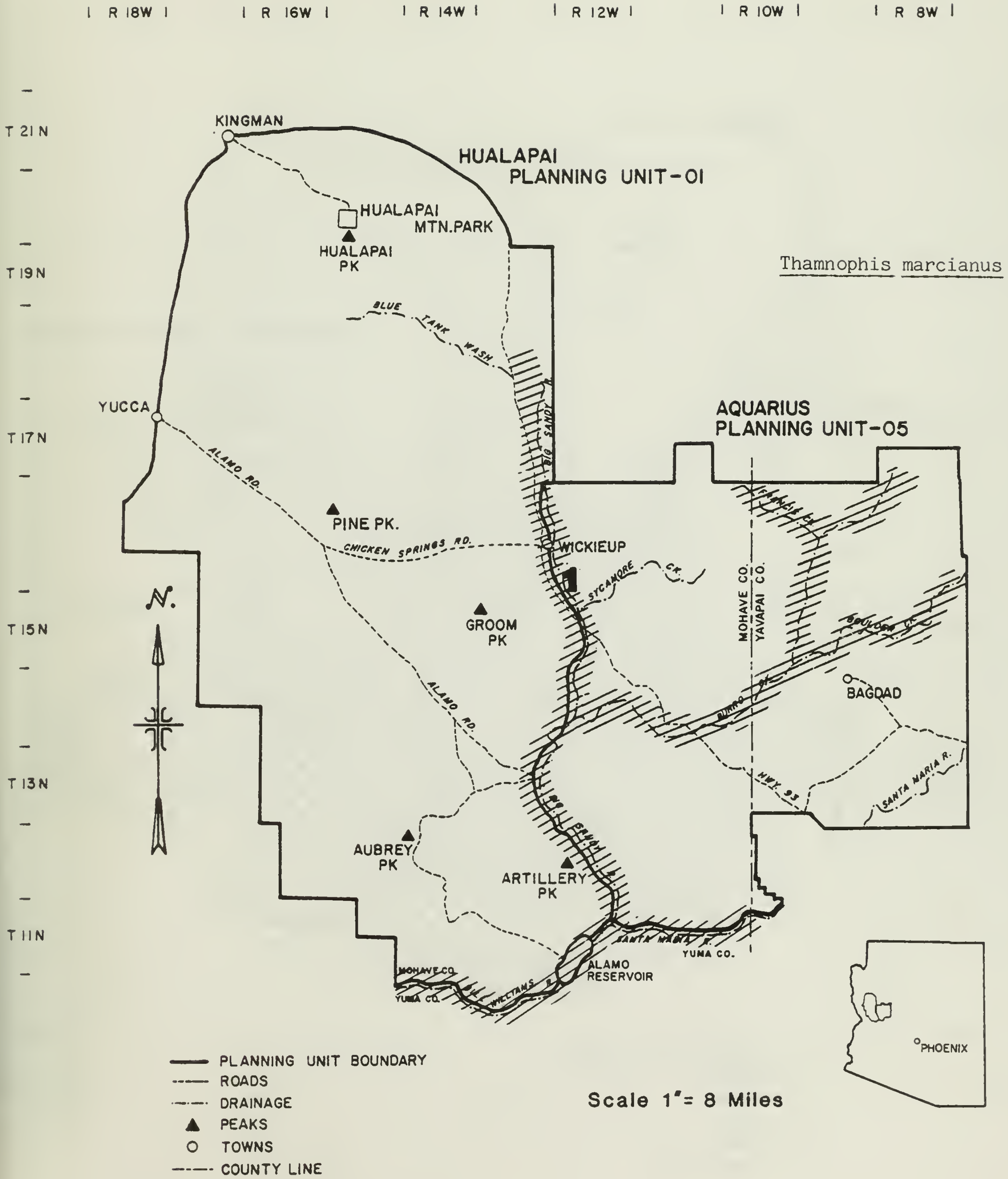
TOWNS
COUNTY LINE
Scale 1" = 8 Miles

Thamnophis cyrtopsis

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PLANNING UNIT-01
HUALAPAI
MTN.PARK
HUALAPAI
PK
Thamnophis marcianus
BLUE TANK WASH
YUCCA
AQUARIUS
PLANNING UNIT-05
ALAMO RD.
PINE PK.
CHICKEN SPRINGS RD.
WICKIEUP
SYCAMORE CK.
MOHAVE CO.
YAVAPAI CO.
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BAGDAD
ALAMO RD.
HWY. 93
SANTA MARIA R.
AUBREY
PK
ARTILLERY
PK
SANTA MARIA R.
YUMA CO.
ALAMO
RESERVOIR
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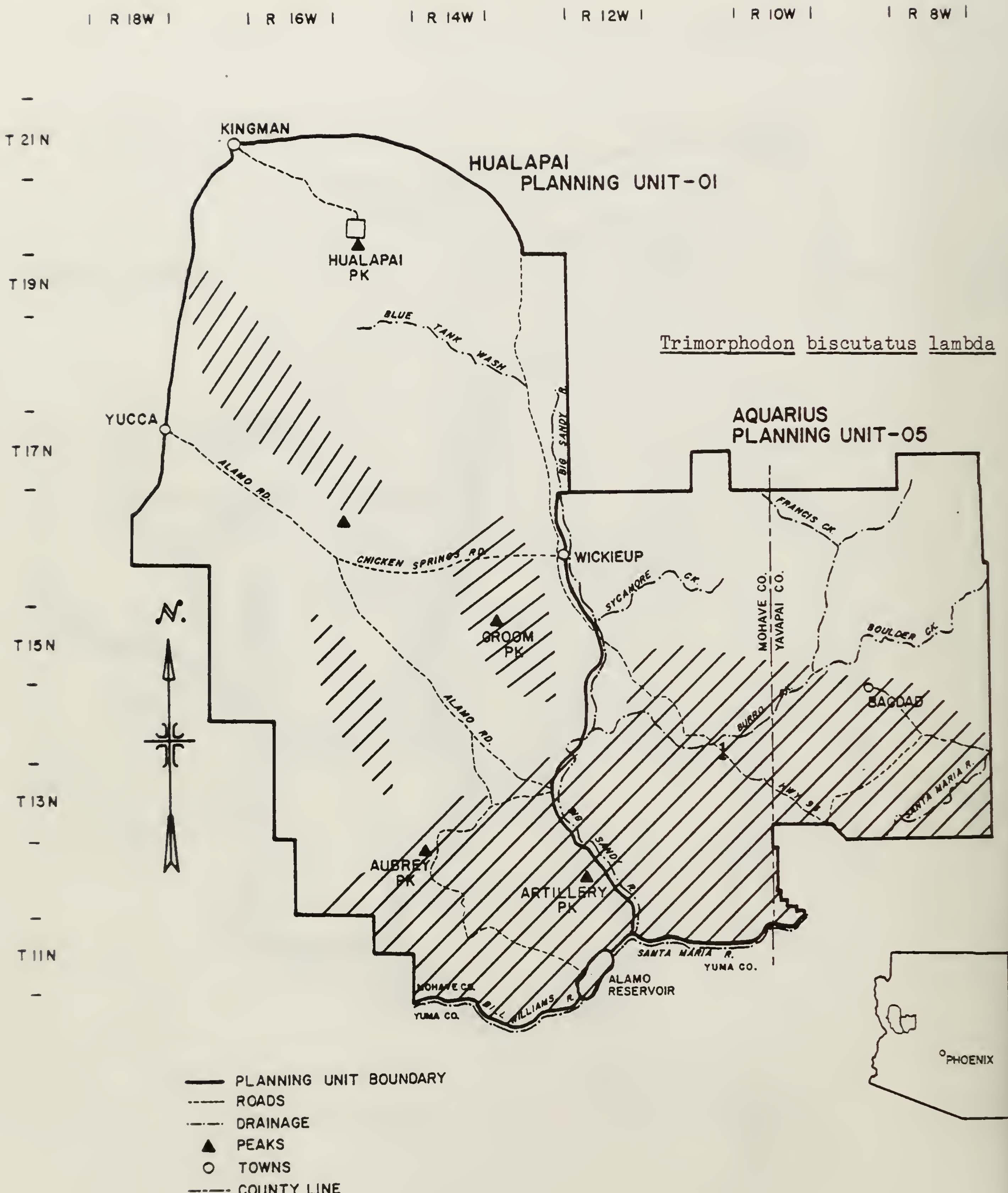
PLANNING UNIT BOUNDARY
ROADS
DRAINAGE
PEAKS
TOWNS
COUNTY LINE
Scale 1"= 8 Miles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KINGMAN
HUALAPAI
PLANNING UNIT-01
HUALAPAI
PK
BLUE TANK WASH
Trimorphodon biscutatus lambda
YUCCA
BIG SANDY R.
AQUARIUS
PLANNING UNIT-05
ALAMO RD.
FRANCIS CK.
CHICKEN SPRINGS RD.
WICKIEUP
SYCAMORE CK.
MOHAVE CO.
YAVAPAI CO.
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GROOM
PK
BOULDER CK.
BAGDAD
ALAMO RD.
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HWY 93
SANTA MARIA R.
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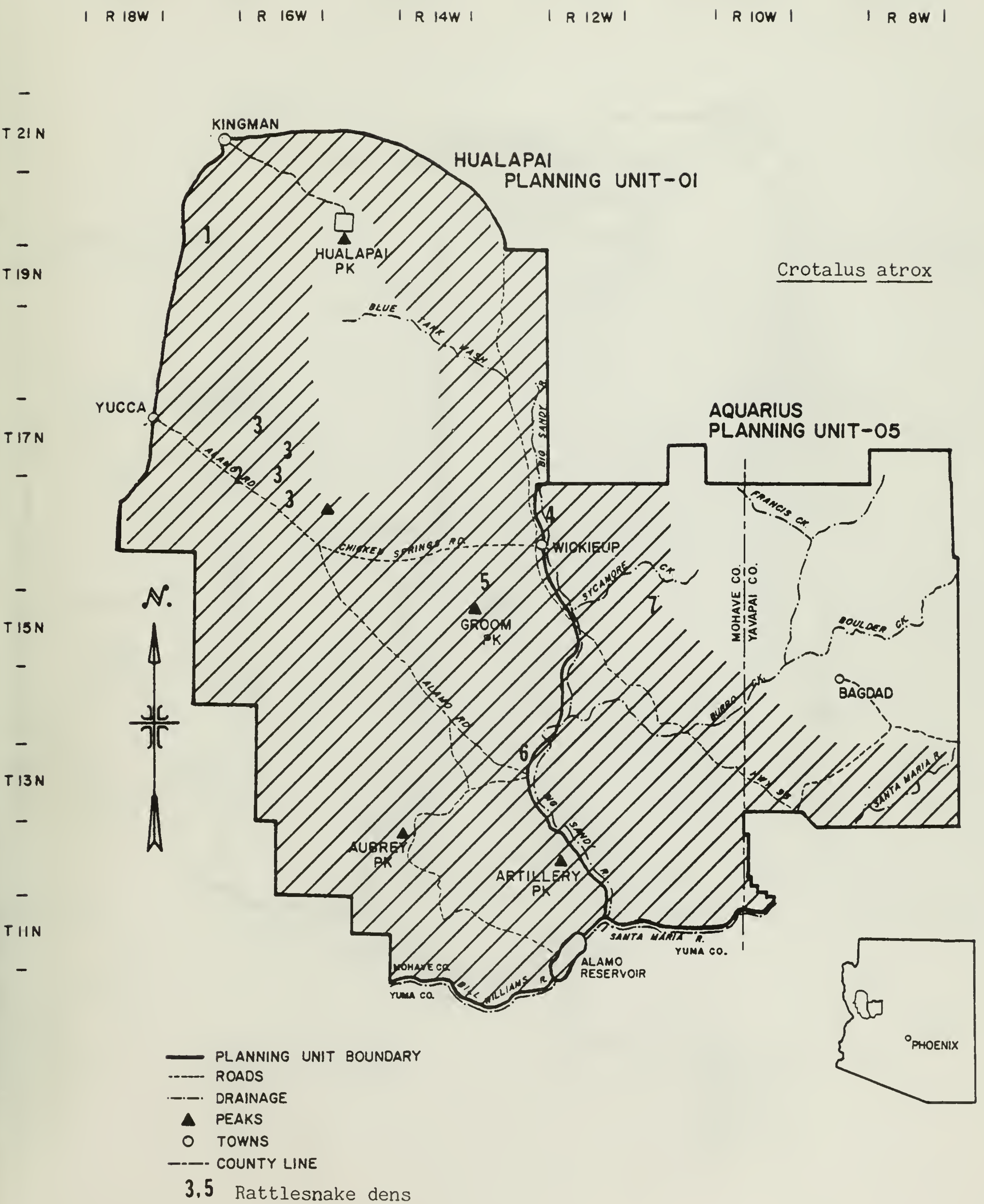
ARTILLERY
PK
SANTA MARIA R.
YUMA CO.
ALAMO
RESERVOIR
MOHAVE CO.
YUMA CO.
BILL WILLIAMS R.
PHOENIX
PLANNING UNIT BOUNDARY
ROADS
DRAINAGE
PEAKS
TOWNS
COUNTY LINE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R 16W
R 14W
R 12W
R 10W
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T 21 N
T 19 N
T 17 N
T 15 N
T 13 N
T 11 N
KINGMAN
HUALAPAI PLANNING UNIT-01
HUALAPAI PK
BLUE TANK WASH
YUCCA
ALAMO RD
BIG SANDY R
AQUARIUS PLANNING UNIT-05
CHICKEN SPRINGS RD
WICKIEUP
FRANCIS CK
SYCAMORE CK
MOHAVE CO.
YAVAPAI CO.
BOULDER CK
GROOM PK
BAGDAD
BURRO CK
ALAMO RD
HWY 93
SANTA MARIA R
AUBREY PK
ARTILLERY PK
SANTA MARIA R.
YUMA CO.
ALAMO RESERVOIR
MOHAVE CO.
YUMA CO.
BILL WILLIAMS R.
N.
PHOENIX
Crotalus atrox
1
3
3
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3
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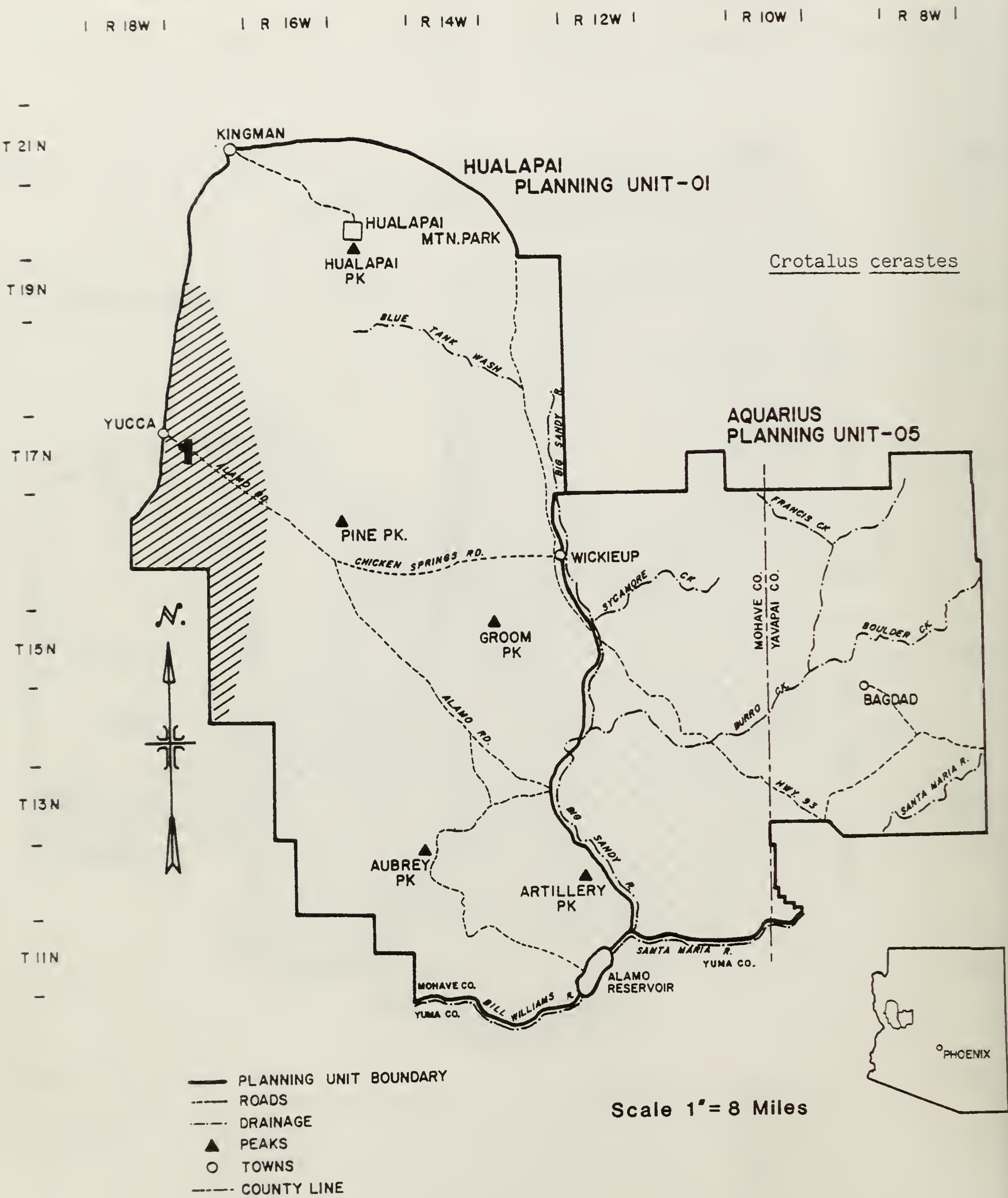
PLANNING UNIT BOUNDARY
ROADS
DRAINAGE
PEAKS
TOWNS
COUNTY LINE
3,5 Rattlesnake dens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KINGMAN
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PLANNING UNIT-01
HUALAPAI
MTN. PARK
HUALAPAI
PK
Crotalus cerastes
BLUE TANK WASH
BIG SANDY R.
YUCCA
AQUARIUS
PLANNING UNIT-05
ALAMO RD.
PINE PK.
CHICKEN SPRINGS RD.
WICKIEUP
FRANCIS CK
SYCAMORE CK
MOHAVE CO.
YAVAPAI CO.
BOULDER CK
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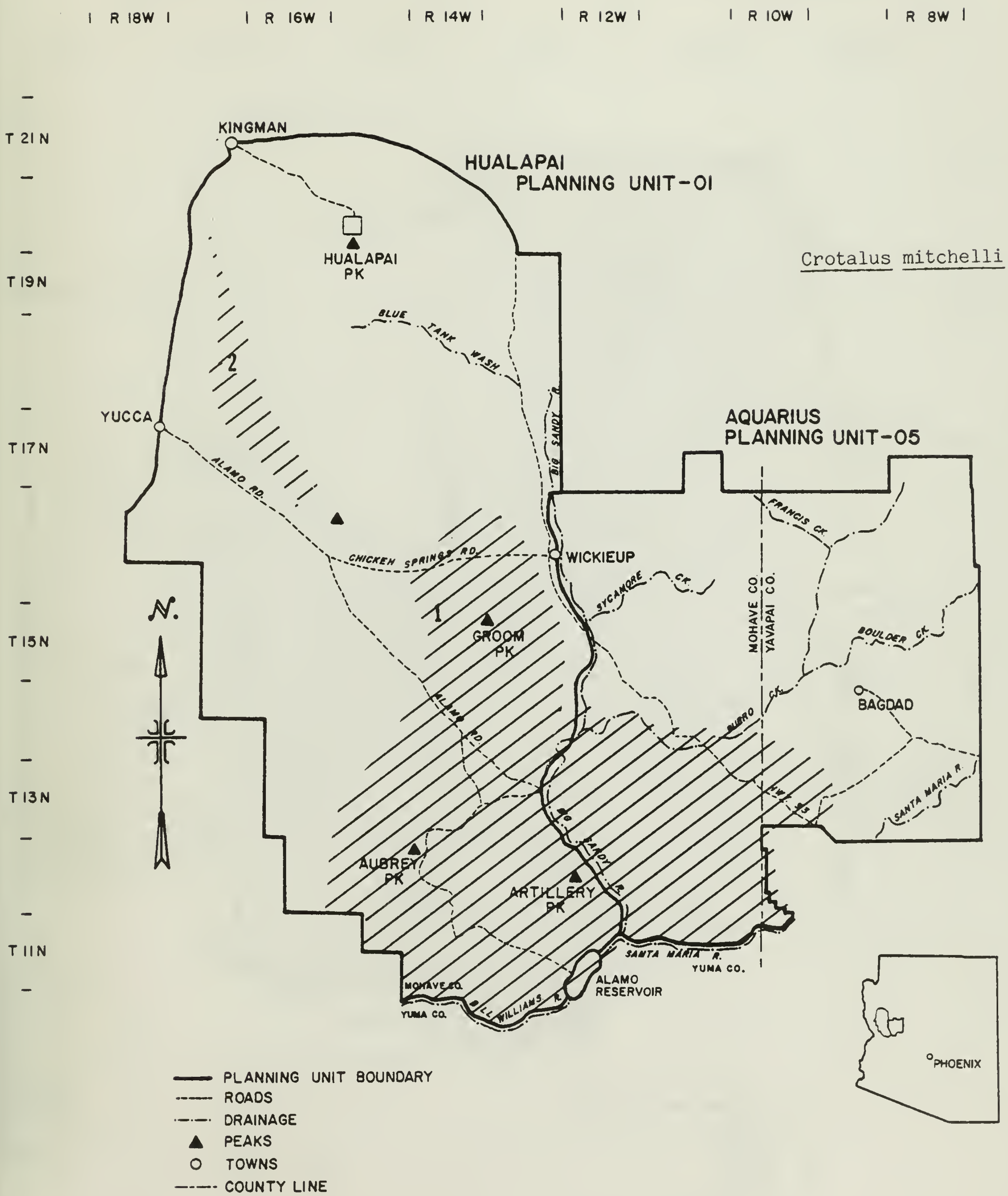
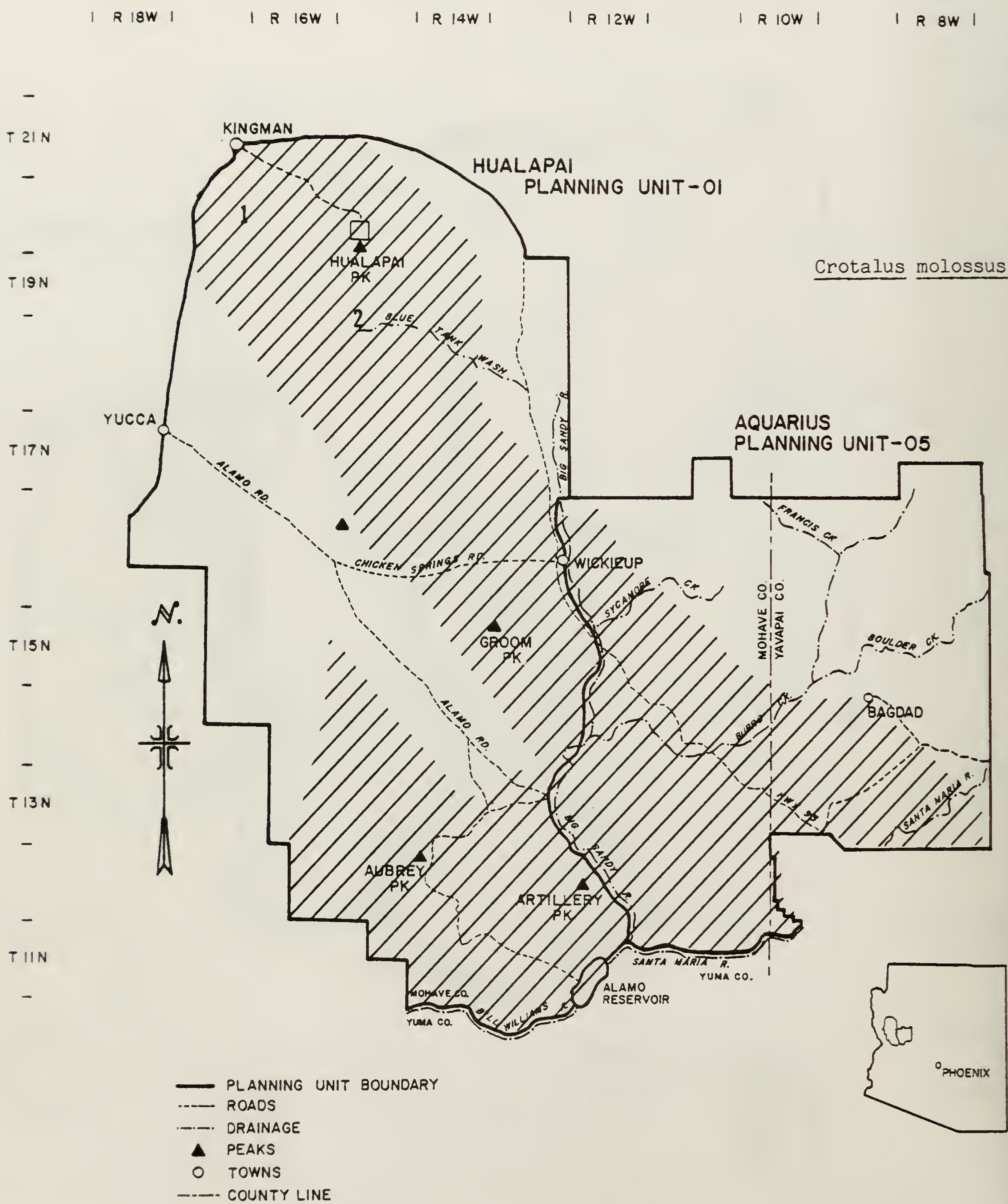
GROOM
PK
BURRO CK
BAGDAD
ALAMO RD.
HWY. 93
SANTA MARIA R.
BIG SANDY R.
AUBREY
PK
ARTILLERY
PK
SANTA MARIA R.
YUMA CO.
ALAMO
RESERVOIR
MOHAVE CO.
YUMA CO.
BILL WILLIAMS R.
PHOENIX
PLANNING UNIT BOUNDARY
ROADS
DRAINAGE
PEAKS
TOWNS
COUNTY LINE
Scale 1" = 8 Miles

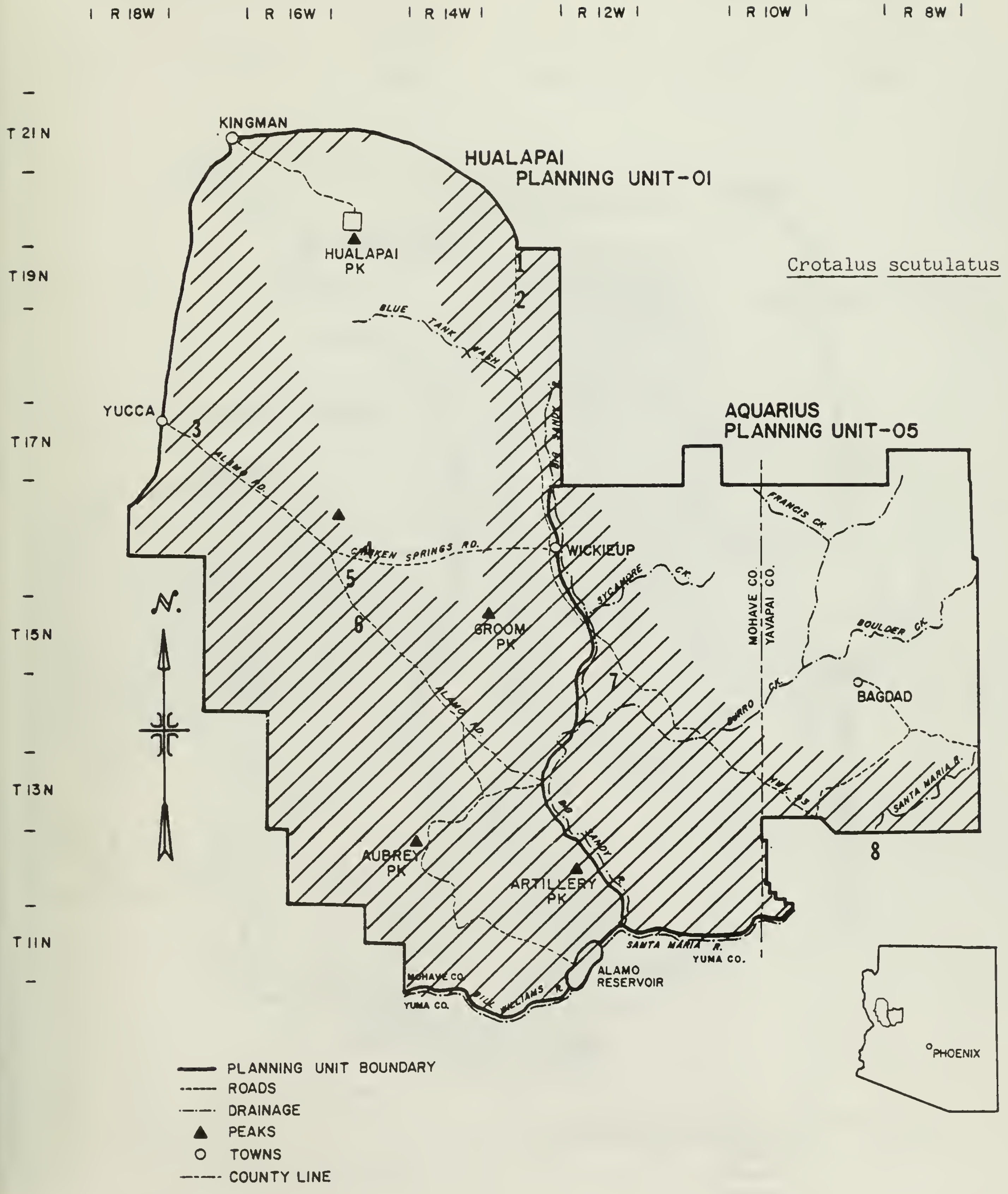


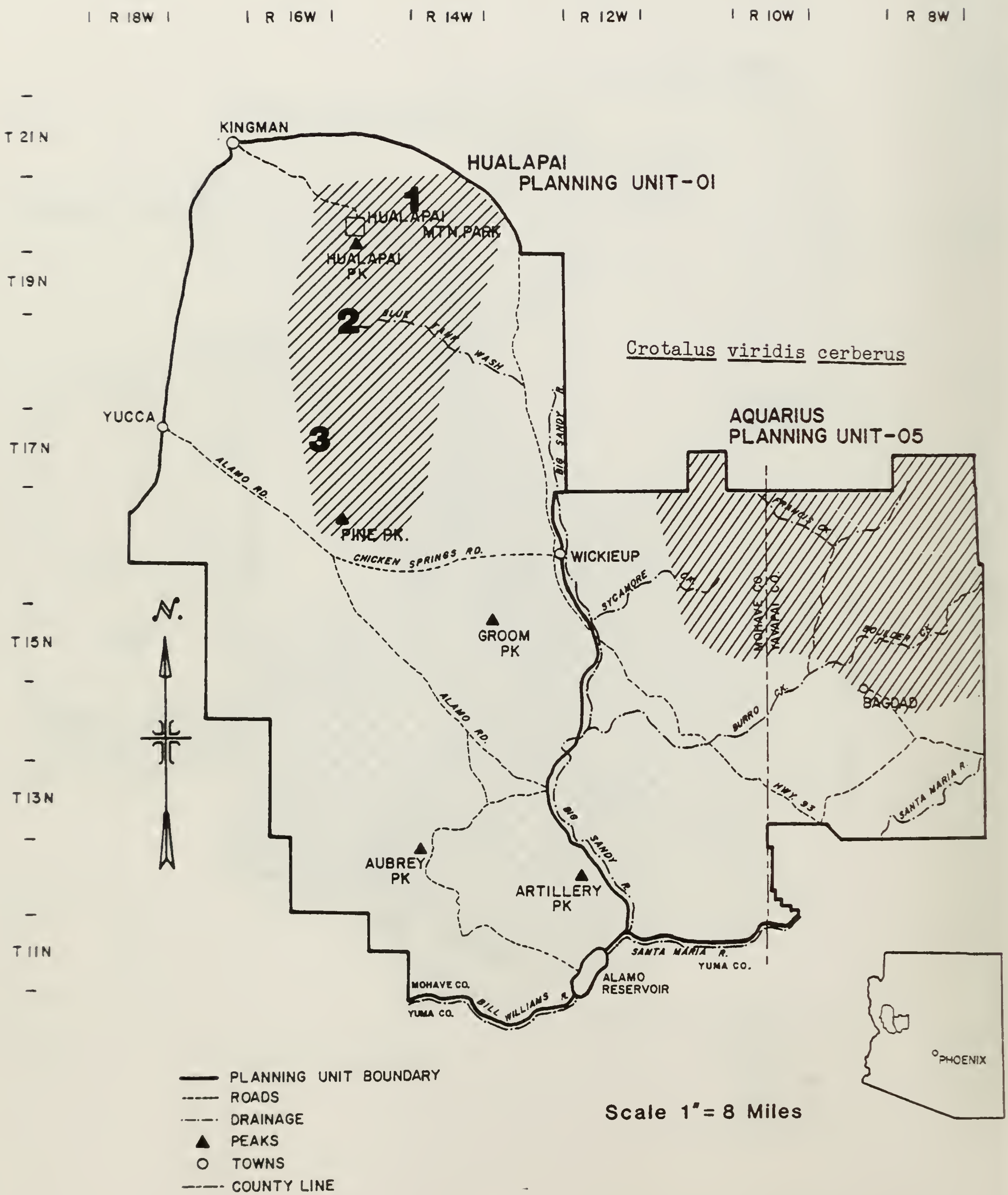
Crotalus mitchelli



Crotalus molossus

Crotalus scutulatus

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KINGMAN
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PLANNING UNIT-01
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HUALAPAI
MTN. PARK
HUALAPAI
PK
2
BLUE
TANK
WASH
Crotalus viridis cerberus
YUCCA
3
ALAMO RD.
BIG SANDY R.
AQUARIUS
PLANNING UNIT-05
PINE PK.
CHICKEN SPRINGS RD.
WICKIEUP
SYCAMORE
CK.
MOHAVE CO.
YAVAPAI CO.
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GROOM
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SANTA MARIA R.
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ARTILLERY
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ALAMO
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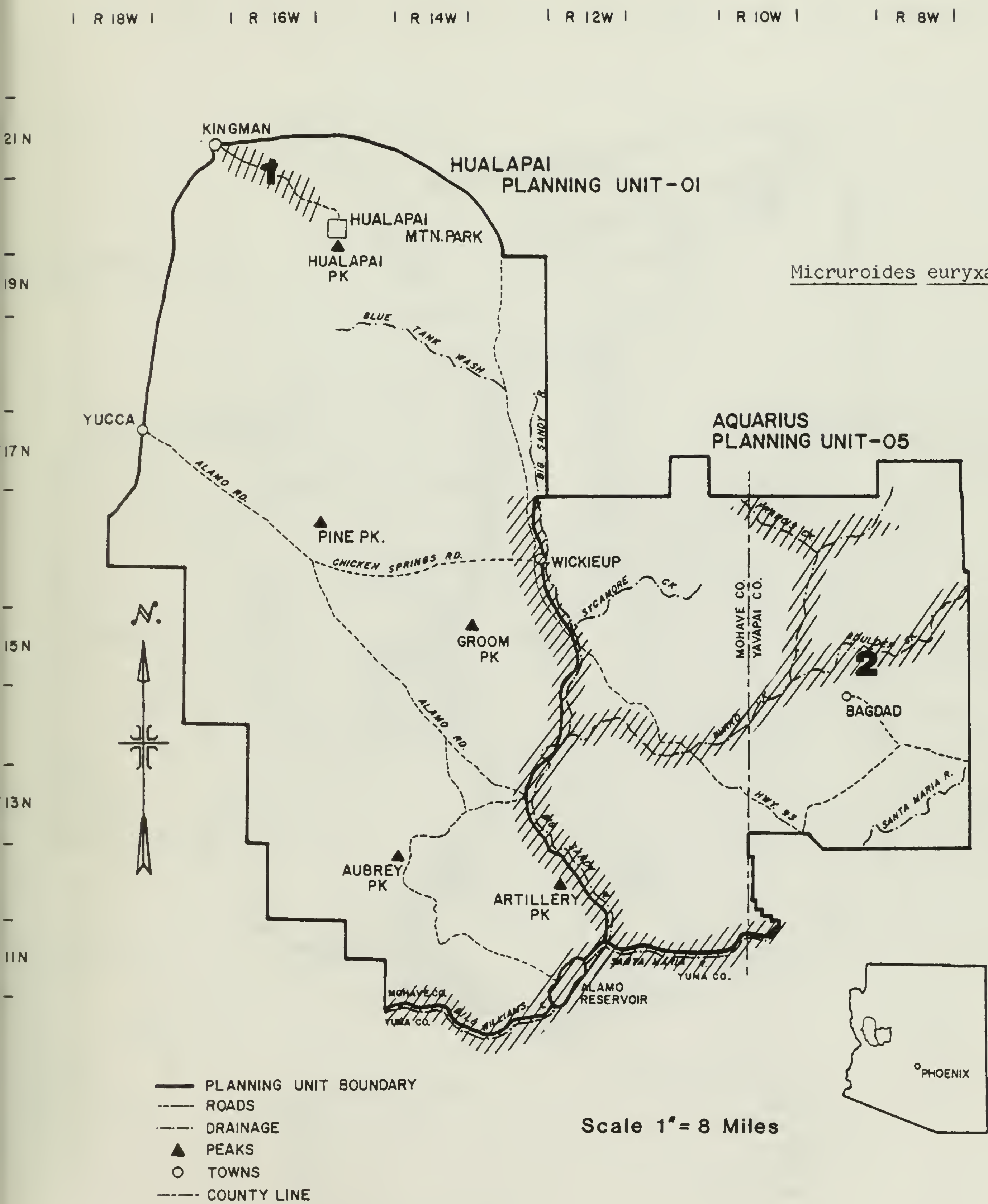
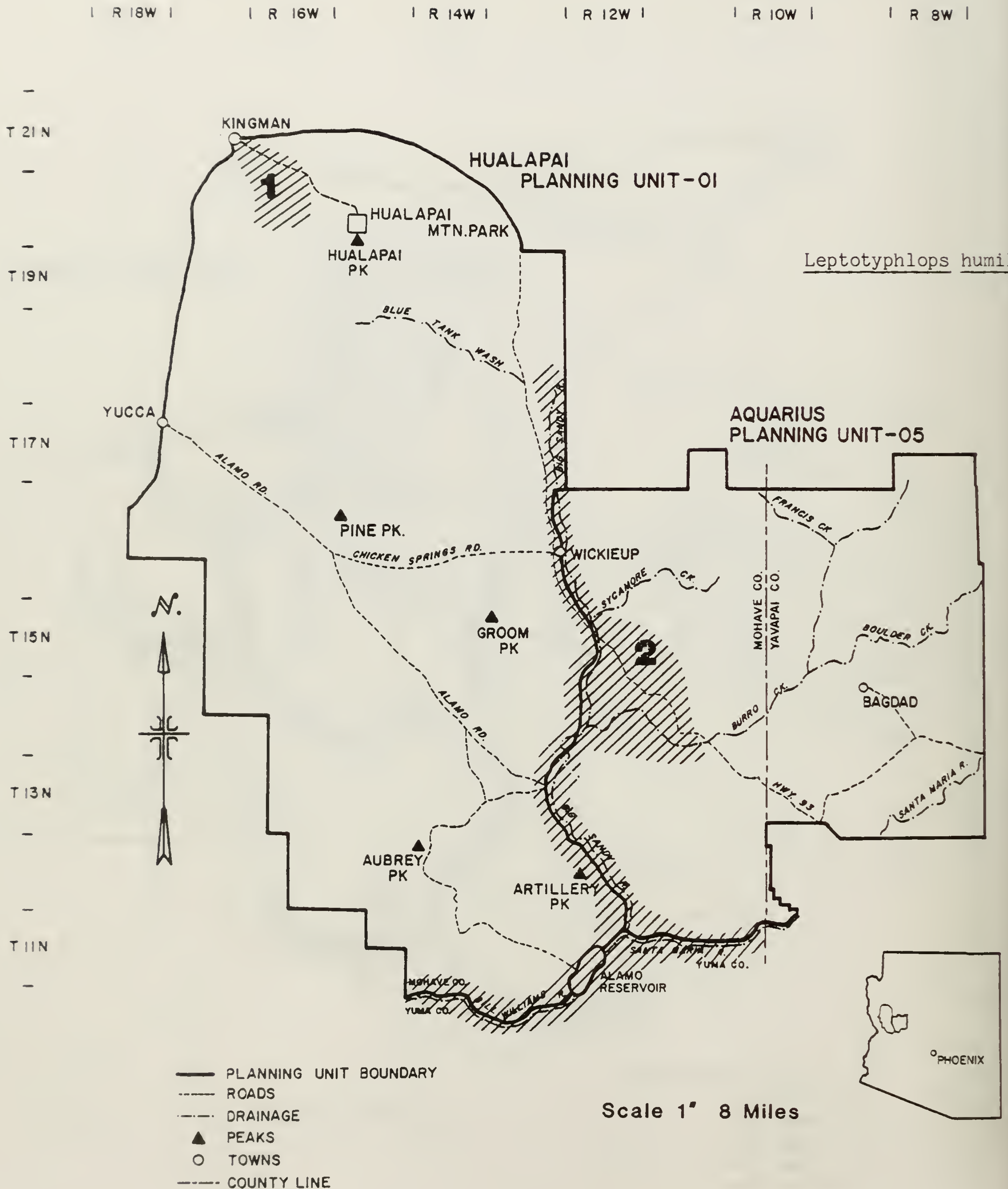
PEAKS
TOWNS
COUNTY LINE
Scale 1" = 8 Miles

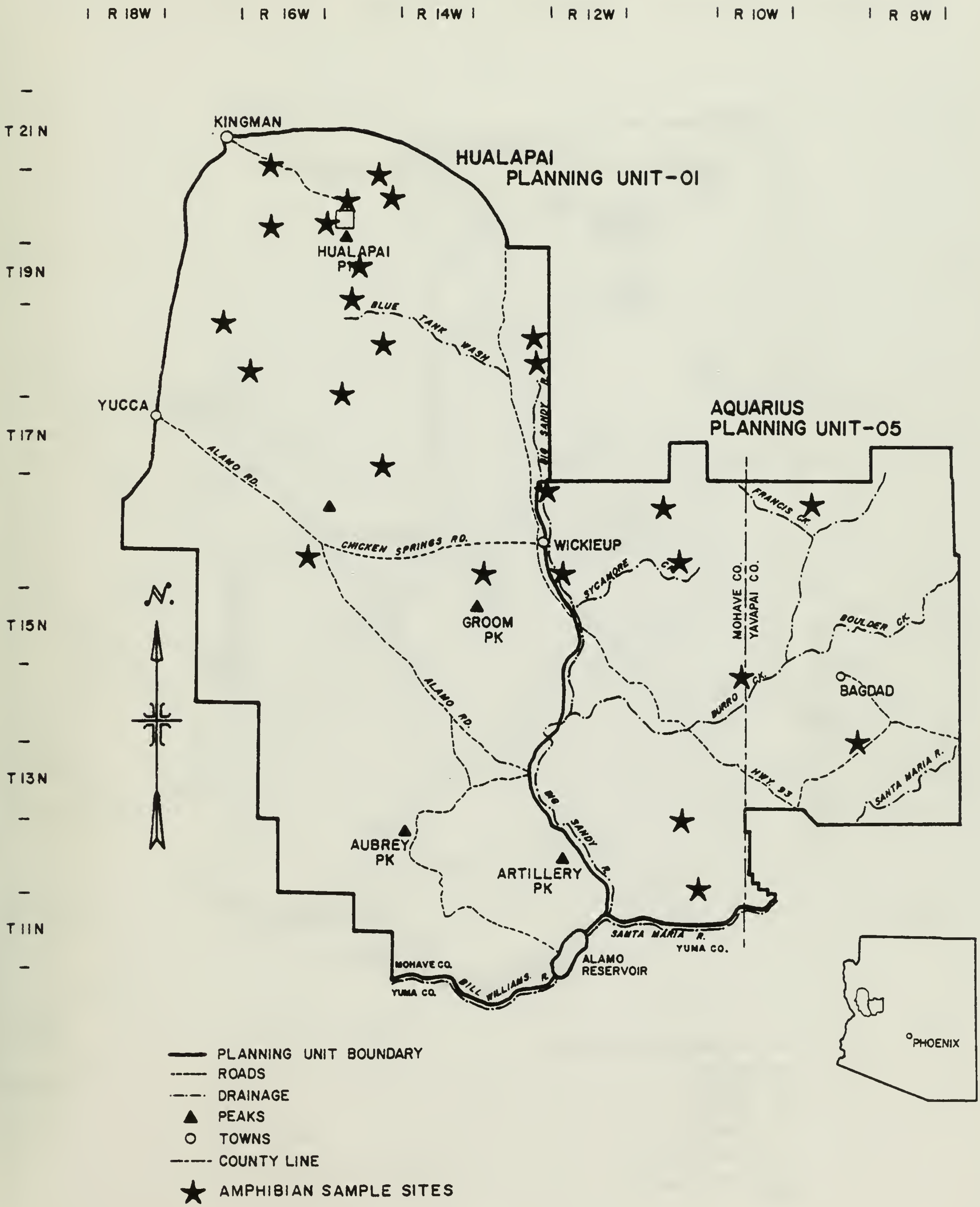
Micruroides euryxanthus



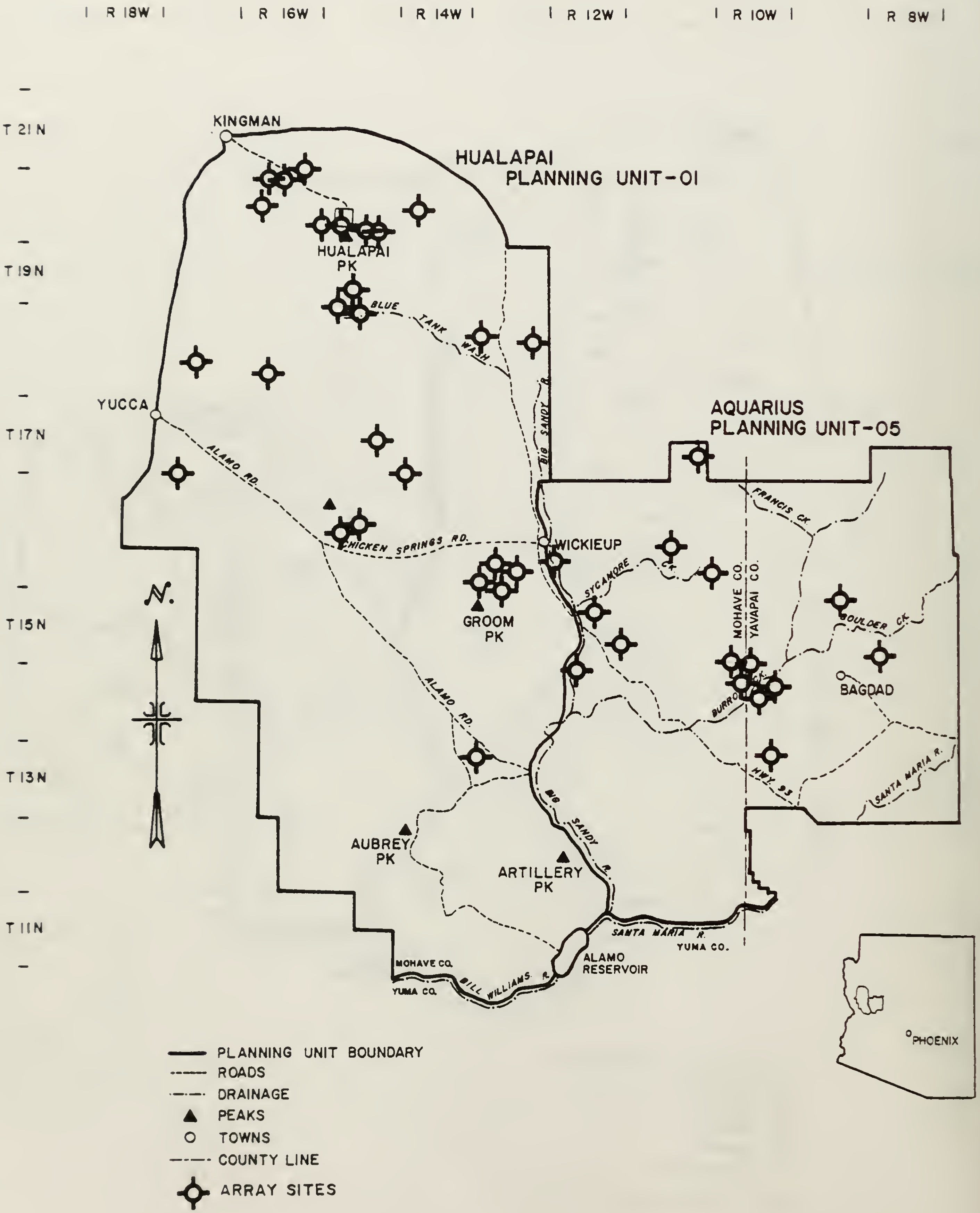


Leptotyphlops humilis

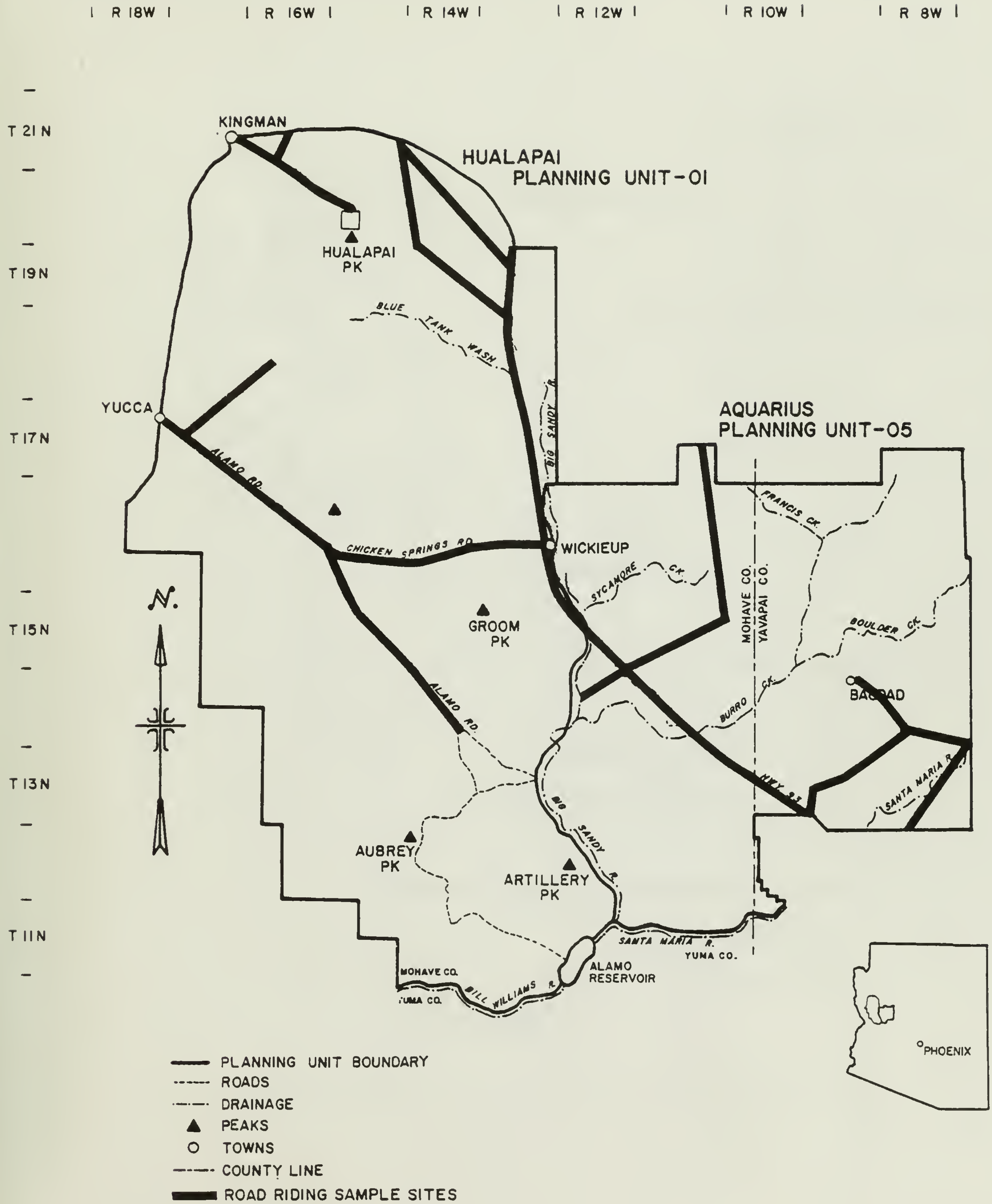
APPENDIX 4 - Amphibian sample sites.



APPENDIX 5 - Array sample sites.



APPENDIX 6 -Road riding sample sites.

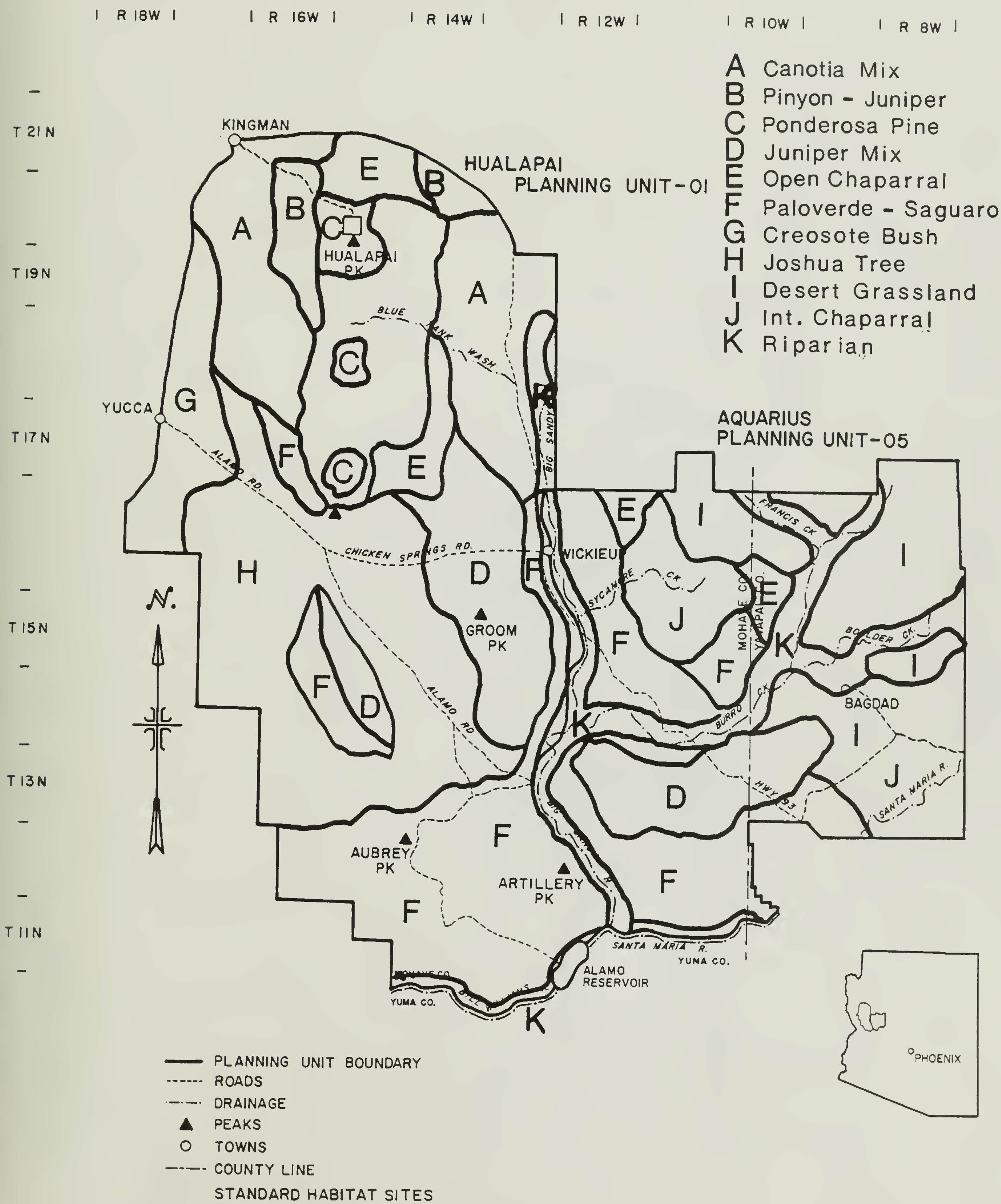


APPENDIX 7 -

Standard Habitat Site Abbreviations

Standard Habitat Site	Abbreviation
Ponderosa Pine	PP
Ponderosa-Aspen	PA
Pinyon-Juniper	PJ
Juniper Mix	JM
Interior (Closed) Chaparral	IC
Open Chaparral	OC
Desert Grassland	DG
Joshua Tree	JT
Creosote Bush	CB
Saguaro-Paloverde (Paloverde-Saguaro)	SP or PS
Canotia Mix	CM
Mixed Broadleaf Riparian (Broadleaf Riparian)	BR
Cottonwood-Willow	CW
Mesquite Bosque	MB

APPENDIX 8 - Standard habitat site distributions within the Hualapai-Aquarius planning area.



Appendix 9. - Conflict areas within the Hualapai-Aquarius planning area.

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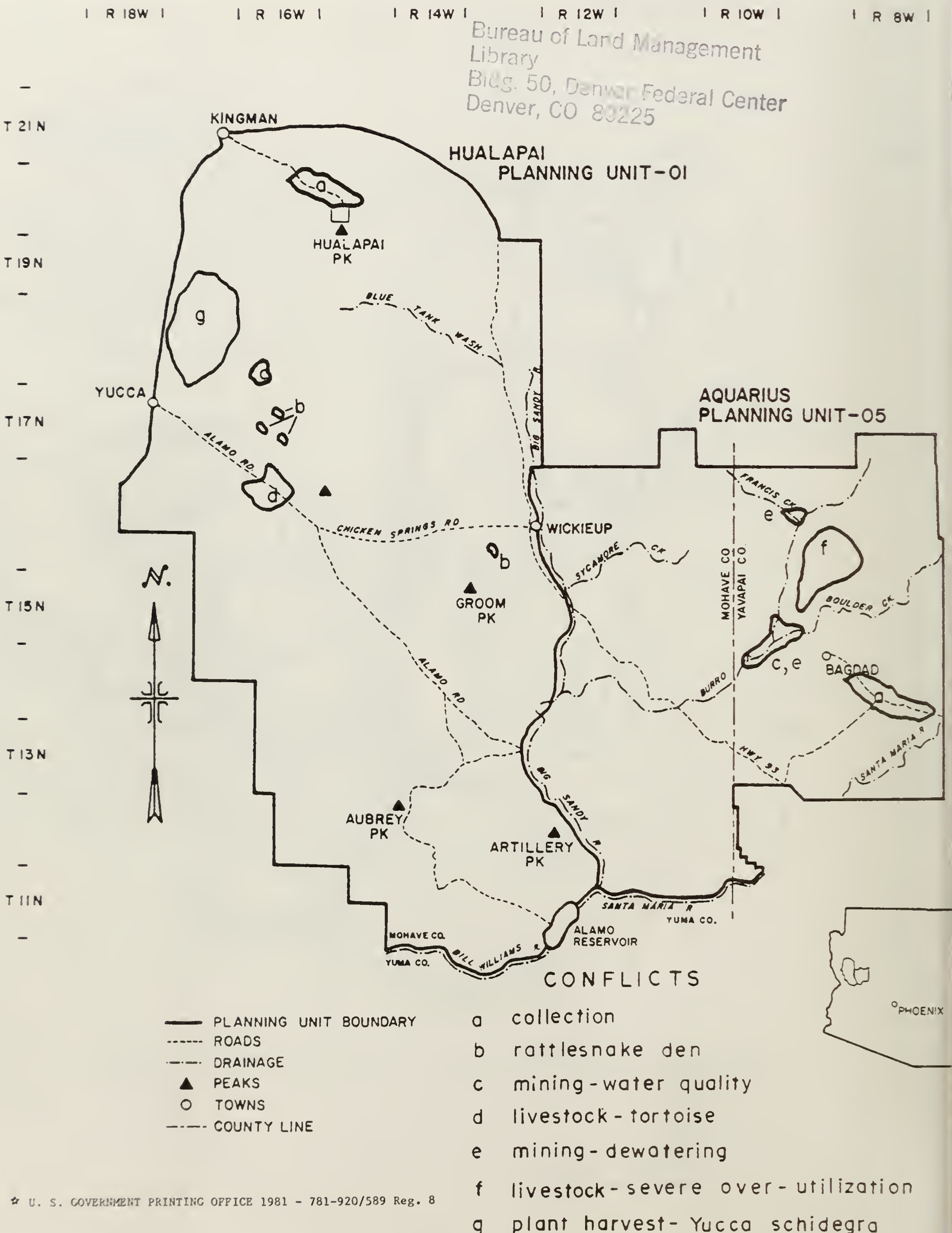

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